

1. Submitted to Beverage Plant Research (24-9-2023)
  - Correspondence
  - Document
2. First Review: Major Revision (7-10-2023)
  - Correspondence
  - Decision Letter
  - Document
3. Second Review: Major Revision (8-12-2023)
  - Correspondence
  - Decision Letter
  - Document
4. Paper Accepted (19-1-2024)
  - Correspondence
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5. Gallery Proofreading (5-5-2024)
  - Correspondence
  - Document
6. Paper Published (19-6-2024)
  - Correspondence
  - Document

1. Submitted to Beverage Plant Research (24-9-2023)
  - Correspondence
  - Document



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**Beverage Plant Research is indexed in Scopus: A Milestone Worth Celebrating!**

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Sat, Aug 26, 2023 at 6:19 PM

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Best regards,



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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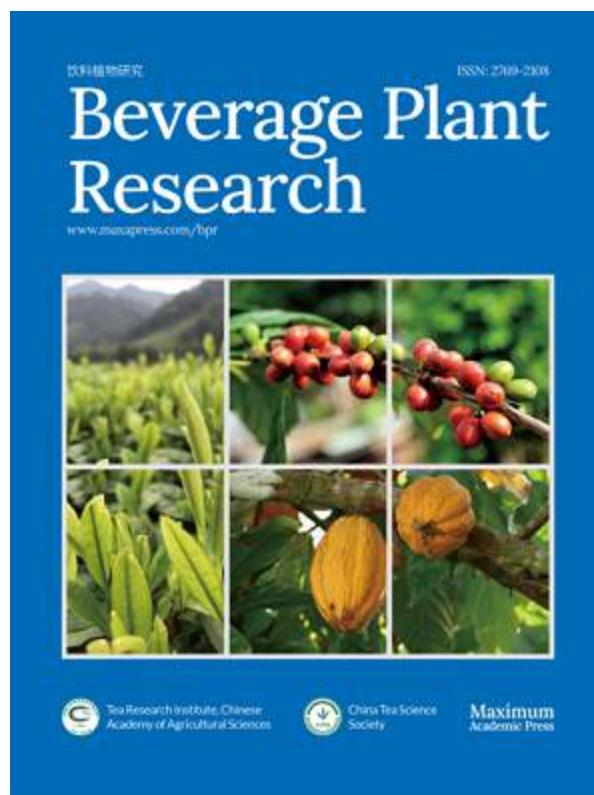
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**Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties and antioxidant activity of wet noodles**

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1 **Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to**  
2 **qualities, sensory properties and antioxidant activity of wet noodles**

3  
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11

12

**Abstract**

13 The improving of wet noodles qualities, sensory and functional properties were done by  
14 using the composite flour base added with the butterfly pea flower extract. The composite flour  
15 of wheat flour, stink lily flour and  $\kappa$ -carrageenan at various ratio of 80:20:0 (K0), 80:19:1 (K1),  
16 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentration of butterfly pea extract  
17 of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed randomized block design with 2  
18 factors, namely the composite flour and the concentration of butterfly pea flower extract that  
19 resulted 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15,  
20 K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower  
21 extract were significantly affected the color, sensory properties, bioactive compounds, and  
22 antioxidant activity of wet noodles. However, each factor had significant influenced of the physical  
23 properties from wet noodles, such as moisture content, water activity, tensile strength, swelling  
24 index and cooking loss. The using of  $\kappa$ -carrageenan up to 3% (w/w) in composite flour increased  
25 moisture content, swelling index and tensile strength but reduced water activity and cooking loss.  
26 K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at ratio of  
27 80:17:3 (% w/w) was the best consumer acceptance based on hedonic sensory score.

28 **Keywords:** composite flour, butterfly pea flower, quality, sensory, wet noodles

29

## 30 **Introduction**

31 Composite flour is a mixture of flour and several types of flour from other ingredients,  
32 which usually come from several types of carbohydrate sources (tubers, legumes, cereals) with or  
33 without wheat flour<sup>[1,2]</sup>. The composite flour is made to obtain suitable material characteristics for  
34 the desired processed product to result certain functional properties<sup>[3]</sup>. The use of composite flour  
35 has been widely carried out to increase the functional values and set the physical, chemical and  
36 sensory quality of the wet noodles. Siddeeg et al.<sup>[4]</sup> uses wheat-sorghum-guar flour and wheat-  
37 millet-guar flour to improve acceptability of wet noodles. Efendi et al.<sup>[5]</sup> informed that potato  
38 starch and tapioca flour at ratio of 50:50 (% w/w) can update the functional values of wet noodles.  
39 Dhull & Sandhu<sup>[6]</sup> claimed that noodles made from a blend of fenugreek flour up to 7% with  
40 wheat flour can produce a good texture and consumer acceptance. Park et al.<sup>[7]</sup> utilizes the blended  
41 ratio of purple-colored wheat bran to increase quality and antioxidant activity of wet noodles.

42 Previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
43 composited with wheat flour to increase the functional values of noodles by increasing the  
44 biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and  
45 prolong gastric emptying time<sup>[8,9]</sup>. However, adding of stink lily flour in base noodles flour had  
46 limited on elasticity and tensile strength of wet noodles<sup>[10,11]</sup>. Then, the  $\kappa$ -carrageenan was added  
47 to improve the texture properties of wet noodles. Those components were a collaborates with  
48 glucomannan to form cross linking with glutenin and gliadin by intern and intra-molecular bonds  
49 leading to improving of noodle texture<sup>[12-14]</sup>. Widyawati et al.<sup>[15]</sup> explained that using of the  
50 composite flour consisted of wheat flour, stink lily flour and  $\kappa$ -carrageenan can look up swelling  
51 index, total phenolic content (TPC), total flavonoid content (TFC) and DPPH free radical  
52 scavenging activity that influences an effectivity of bioactive compounds on composite flour as



53 antioxidant of wet noodles. Therefore, addition of the other ingredient enriched phenolic  
54 compounds is done to increase functional values of composite flour as antioxidant. Czajkowska–  
55 González et al. [16] informed that elaborate of natural antioxidant sources enriched phenolic  
56 compounds can improve functional values of bread. Widyawati et al. [15] has added pluchea extract  
57 to increase TPC, TFC and DPPH free radical scavenging activity of wet noodles, but the weakness  
58 of wet noodle color is not attractive that it is necessary to look for other ingredients, one of which  
59 is butterfly pea flower.

60 Butterfly pea (*Clitoria ternatea*) is an herb plant, Fabaceae family, having various color  
61 flower, such as purple, blue, pink, and white [17]. This flower has phytochemical compounds which  
62 are benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids,  
63 flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides  
64 [20,21]. Anthocyanins of the butterfly pea flower has been used as natural color in many food  
65 products [22,23], one of them is wet noodles [24,25]. The phytochemical compounds, especially  
66 phenolic compounds, can influence the interaction among gluten, amylose and amylopectin  
67 depend on partition coefficients, keto-groups, double bonds (in the side chains), and the benzene  
68 ring [26]. This interaction involves covalent and non-covalent bonds of them which were influenced  
69 pH and determined hydrophilic-hydrophobic properties and protein digestibility [27]. Previous  
70 study has proven that the use of phenolic compounds from plant extract, such as pluchea leaf [15,28],  
71 gendarussa leaf (*Justicia gendarussa* Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31]  
72 establishes the quality, bioactive compounds, antioxidant activity and sensory properties of wet  
73 noodles. Shiau et al. [25] has utilized natural color of butterfly pea flower extract to make wet  
74 noodles base wheat flour that results the higher total anthocyanin, polyphenol, DPPH scavenging  
75 activity and reducing power than the control samples and the use of this extract can improve color

76 preference and reduce the cutting force, tensile strength, and extensibility of cooked noodles. Until  
77 now, the application of water extract of butterfly pea flowers in wet noodles has been commercially  
78 produced but the interactions among phytochemical compounds and ingredients of wet noodles  
79 base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) has not been studied.  
80 Therefore, the study was conducted to decide the effect of composite flour and butterfly pea flower  
81 extract to quality, bioactive content, antioxidant activity, and sensory properties of wet noodles.

## 82 **Materials and Methods**

### 83 **Raw materials and preparation**

84 Butterfly pea flower was obtained from Penjaringan Sari garden, Wonorejo, Rungkut,  
85 Surabaya, Indonesia. The flower was sorted, washed, dried by open sunlight, powdered using  
86 blender (Philips HR2116, PT Philips, Netherlands) for 3 min, sieved using a sieve shaker with 45  
87 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water  
88 extract of butterfly pea flower was obtained using hot water extraction at 95°C for 3 min to get  
89 three concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three  
90 composite flours proportion were prepared with a mixing of wheat flour (Cakra Kembar, PT  
91 Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok  
92 Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratio of  
93 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### 94 **Chemical and reagents**

95 The gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin and sodium carbonate  
96 were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin–  
97 Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium  
98 hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide,

99 chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA).  
100 Distillated water was purchased by local market (PT Aqua Surabaya, Surabaya, Indonesia).

### 101 **Wet noodles preparation**

102 Wet Noodles were prepared based on the modified formula of Panjaitan et al. [11] as shown  
103 in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with  
104 butterfly pea flower extract at various concentration. The salt, water, fresh whole egg was then  
105 added and kneaded to make dough by using a mixer machine (Oxone Master Series 600 Standing  
106 Mixer OX 851, China). The dough was sheeted and cut via rollers using cutting blades (Oxone  
107 OX355AT, China). Wet noodles were sprinkled with tapioca flour before heated in boiled water  
108 (100°C) with a ratio of raw noodles /water at 1:4 w/v for 2 min. Cooked wet noodles were coated  
109 with palm oil before subjected to measure the quality and sensory properties but the samples  
110 without cooking and oil coating were used to analyze the bioactive compounds and antioxidant  
111 activity.

### 112 **Extraction of bioactive compounds of wet noodles**

113 Wet noodles were extracted based on the method of Widyawati et al. [15]. Raw noodles  
114 were dried in cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at  
115 60°C for 2 h. The dried noodles were grinded using a chopper (Dry Mill Chopper Philips set HR  
116 2116, PT Philips, Netherlands). The 20 g of samples were mixed with 50 mL of solvent mixture  
117 (1:1 v/v of methanol /water) and stirred at 90 rpm in shaking water bath at 35°C for 1 h and  
118 centrifuged at 5000 rpm for 5 min to obtain the supernatant. The residue obtained was re-extracted  
119 in the extraction time for 3 intervals. Supernatant was evaporated using rotary evaporator (Buchi-  
120 rotary evaporator R-210, Germany) at condition of 70 rpm, 70°C, and 200 mbar to result  
121 concentrated wet noodles. Then, the extract was used for further analysis.

122

**123 Moisture content analysis**

124 Water content of cooked wet noodles was analyzed based on thermogravimetry method<sup>[32]</sup>.

125 1 g samples were weighed in weighing bottle and heated by drying oven at 105-110°C for 1 h, then

126 samples were weighed and measured moisture content after weight of samples was constant.

127 Moisture content is calculated based on the difference in sample weight before and after a constant

128 weight is reached divided by the initial sample weight expressed as a percentage of wet base.

**129 Water activity analysis**

130 Water activity of cooked wet noodles was analyzed using Aw-meter (Water Activity

131 Hygropalm HP23 Aw a set 40 Rotronic, Swiss). 10 g samples were weighed and entered in Aw

132 meter chamber, analyzed and data recorded<sup>[33]</sup>.

**133 Tensile strength analysis**

134 Tensile strength is essential parameter that measures extensibility of cooked wet

135 noodles<sup>[39]</sup>. 20 cm samples were measured tensile strength using texture analyzer that be equipped

136 by Texture Exponent Lite Program and used noodle tensile rig probe (TA-Xt Plus, Stable

137 Microsystem, UK). The noodle tensile rig was set to be pre-set speed, test speed, post-test speed 1

138 mm/s, 3 mm, 10 mm/s, respectively. Distance, time, and trigger force were used 100 mm, 5 sec

139 and 5 g, respectively.

**140 Color analysis**

141 10 g cooked wet noodles were weighed in chamber and analyzed color using color rider

142 (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[35]</sup>. Parameter measurement

143 was lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), Hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value is ranged 0-

144 100 that expressed brightness,  $a^*$  value shows red color which has an interval between -80 - +100.

145  $b^*$  value is yellow color that has an interval  $-70 - +70$  [36].  $C$  declares color intensity and  $^o h$  states  
146 color of samples [37].

#### 147 **Swelling index analysis**

148 Swelling index was determined on the modified method of Islamiya et al. [38]. 5 g raw wet  
149 noodles were weighed in chamber and cooked in 150 mL boiled water (100°C) for 5 min. The  
150 swelling index was analyzed to measure capability of raw wet noodles to absorb water that weight  
151 of raw wet noodles increased [39]. The swelling index was measured from difference in noodle  
152 weight before and after boiling.

#### 153 **Cooking loss analysis**

154 Cooking loss of raw wet noodles was analyzed on the modified method of Aditia et al. [40].  
155 The cooking loss expresses weight loss of wet noodles for cooking that is signed by the cooking  
156 water cloudy and thick [41]. 5 g raw wet noodles were weighed in chamber and cooked in 150 mL  
157 boiled water (100°C) for 5 min, then samples were drained and dried by drying oven at 105°C until  
158 the weight of the samples was constant.

#### 159 **Total phenolic content analysis**

160 Total phenolic content of wet noodles was determined using Folin-Ciocalteu's phenol  
161 reagent based on the modified method of Eyele et al. [42]. 50  $\mu\text{L}$  of extract was added 1 mL of 10%  
162 Folin-Ciocalteu's phenol reagent in 10 mL volumetric flask, shaken and incubated for 5 min.  
163 Then, 2 mL of 7.5 %  $\text{Na}_2\text{CO}_3$  was added and the volume was adjusted to 10 mL with distilled  
164 water. Solution was measured absorbance at  $\lambda$  760 nm (Spectrophotometer UV-Vis 1800,  
165 Shimadzu, Japan). The standard reference was used gallic acid and the result was expressed as mg  
166 GAE (Gallic Acid Equivalent) per kg of dried noodles.

167

**168 Total flavonoid content analysis**

169 Total flavonoid content was analyzed on the modified method using Li et al. [2013]. 250  $\mu\text{L}$   
170 of noodle extract was added with 0.3 mL of 5%  $\text{NaNO}_2$  and incubated for 5 min in a 10 mL  
171 volumetric flask. After 5 min of incubation, 0.3 mL of 10%  $\text{AlCl}_3$  was added. After 5 min, 2 mL  
172 of 1 M  $\text{NaOH}$  was added and the volume was adjusted to 10 mL with distilled water. Samples  
173 were mixed and homogenized before was analyzed using spectrophotometer (Spectrophotometer  
174 UV-Vis 1800, Shimadzu, Japan) at  $\lambda$ . 510 nm. The result was determined using (+)-catechin  
175 standard reference and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

**176 Total anthocyanin content analysis**

177 Total anthocyanin content was determined on the method of Giustl and Wrolstad [44]. 250  
178  $\mu\text{L}$  samples were added buffer solution at pH 1 and pH 4.5 in 10 mL test tube. And then each of  
179 samples was mixed and incubated for 15 min and measured at  $\lambda$  543 and 700 nm  
180 (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Absorbance (A) of samples was calculated  
181 with formula:  $A = (A_{\lambda 543} - A_{\lambda 700})_{pH 1.0} - (A_{\lambda 543} - A_{\lambda 700})_{pH 4.5}$ . The total anthocyanin  
182 content (mg/mL) was calculated by formula:  $\frac{A \times MW \times DF \times 1000}{\epsilon \times l}$ . Where A was absorbance, MW was  
183 molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was factor of sample dilution, and  
184  $\epsilon$  was absorptivity molar of delphinidin-3-glucoside (29000  $\text{L cm}^{-1} \text{mol}^{-1}$ ).

**185 DPPH free radical scavenging activity**

186 DPPH scavenging activity was measured based on method of Shirazi et al. [45] and  
187 Widyawati et al. [46]. Briefly, 10  $\mu\text{L}$  extract was added to a 10 mL test tube containing 3 mL of  
188 DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room.  
189 Solution was centrifuged at 5000 rpm for 5 min and absorbance of samples was measured at  $\lambda$ .  
190 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant activity of samples was

191 stated as inhibition capacity with gallic acid as standard reference and expressed as mg GAE  
192 (Gallic Acid Equivalent) per kg of dried noodles.

### 193 **Ferric reducing antioxidant power**

194 FRAP analysis was used the modified method of Al-Temimi and Choundhary <sup>[47]</sup>. 50  $\mu$ L  
195 of extract in a test tube was added 2.5 mL of phosphate buffer solution at PH 6.6 and 2.5 mL of  
196 1% potassium ferric cyanide, shaken and incubated for 20 min at 50°C. After incubation 20 min,  
197 solution was added 2.5 ml of 10% mono chloroacetic acid and shaken. Then, 2.5 mL of supernatant  
198 was taken and added 2.5 mL of bi-distillated water and 2.5 mL of 0.1% ferric chloride and  
199 incubated for 10 min. After incubation, samples were measured absorbance at  $\lambda=700$  nm  
200 (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant capacity was used gallic acid  
201 as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

### 202 **Sensory evaluation**

203 Sensory properties of cooked wet noodles were analyzed on the modified method using  
204 Nugroho et al. <sup>[48]</sup> based on hedonic scale scoring, including color, aroma, taste, and texture  
205 attributes with 15 level, score 1 was stated very dislike and 15 was very like. This sensory analysis  
206 used 100 untrained panelists who had previously gained knowledge of the measurement procedure  
207 with ages between 17 until 25-year-old. The best treatment was determined by index effectiveness  
208 test.

### 209 **Design of experiment and statistical analysis**

210 Design of experiment used a randomized block design (RBD) with two factors, i.e., the  
211 four ratios of the composite flour (wheat flour, stink lily flour and  $\kappa$ -carrageenan) including  
212 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea  
213 flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was done in

214 three replications. The homogenous data of triplicate analysis was expressed as the mean  $\pm$  SD.  
215 The one-way analysis of variance (ANOVA) was done and Duncan's New multiple range test  
216 (DMRT) was used to determine for differences between means ( $p \leq 0.05$ ) using the statistical  
217 analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## 218 **Results and discussions**

### 219 **Quality of Wet Noodles**

220 Quality of wet noodles including moisture content, water activity, tensile strength, swelling  
221 index, cooking loss, and color was shown in Table 2 and Fig.1, 2, 3, and 4. Moisture content and  
222 water activity (AW) of raw wet noodles were only significantly influenced the various ratio of  
223 composite flour ( $p \leq 0.05$ ) (Fig. 1). However, the interaction of two factors, the difference in the  
224 ratio of composite flour and the concentration of butterfly pea extract or the concentration of  
225 butterfly pea extract itself, did not have a significant effect on the water content and AW of wet  
226 noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70 % wet base)  
227 compared to K0 (68 % wet base), K1 (68 % wet base), and K2 (69 % wet base) because the samples  
228 had the highest ratio of  $\kappa$ -carrageenan. The increasing of  $\kappa$ -carrageenan proportion influenced the  
229 amount of free and bound water in the wet noodle samples that increased the water content of wet  
230 noodles. Water content measures the amount of free and weakly bound water in the pores,  
231 intermolecular, and intercellular space of samples [15,28,49]. Protein networking between gliadin and  
232 glutelin forms a three-dimensional networking structure of gluten involving water molecule [50].  
233 The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of  
234 gluten network to stability gluten network that increases water binding capacity and retards the  
235 migration of water molecules [51,52].  $\kappa$ -carrageenan can bind water molecule around 25-40 times  
236 [53]. The  $\kappa$ -carrageenan can cause the structure change of gluten protein though electrostatic



237 interactions and hydrogen bonding <sup>[54,55]</sup>. Interaction among protein of wheat flour (gliadin and  
238 glutelin), glucomannan of stinky lily flour and  $\kappa$ -carrageenan also changed the conformation of  
239 the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds,  
240 intra-and inter-molecular disulfide bonds that is be able to establish water mobility in dough of  
241 this wet noodles. The effect of this interaction of all components of composite flour significantly  
242 influenced of the amount of free water ( $p \leq 0.05$ ) (Fig. 1). The addition of  $\kappa$ -carrageenan between  
243 1-3% in the wet noodle formulation reduced the AW about 0.005-0.006. The capability of  $\kappa$ -  
244 carrageenan absorbed water molecules reduces the water mobility in wet noodles due to the  
245 involving of hydroxyl, carbonyl, and ester sulphate groups of them to form complex structure <sup>[55-  
246 57]</sup>. The complexity of the reaction among components in wet noodles to form a three-dimensional  
247 networking influenced the amount of free water molecules that determined water activity values.  
248 The strength of the bonding among the components arranged of wet noodles and water molecules  
249 also specified the value of the water activity.

250 Tensile strength, swelling index, and cooking loss of cooked wet noodles was significant  
251 influenced by each factors of the composite flour or the concentration of butterfly pea flower  
252 extract ( $p \leq 0.05$ ) (Fig. 1 and 2), but the interaction of the various ratio of composite flour and the  
253 concentration of butterfly pea extract was not significant influenced the tensile strength, swelling  
254 index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). The increasing of the ratio of  $\kappa$ -  
255 carrageenan in composite flour increased the tensile strength and swelling index, and decreased  
256 cooking loss of wet noodles, but the increasing of the concentration of butterfly pea extract  
257 decreased the tensile strength and increased swelling index and cooking loss of wet noodles. The  
258 effect of the ratio of composite flour to the tensile strength ranged between 0.197 to 0.171 g. While  
259 the addition of butterfly pea extract caused the tensile strength of wet noodles (T15 and T30)

260 significant lower around 0.003 until 0.008 than control (K1). The highest swelling index values  
261 was owned by K3 sample and the lowest swelling index values were belonging of the K0 sample.  
262 The swelling index values of wet noodles ranged around 128 to 159 %. The effect of composite  
263 flour proportion of wet noodles showed that K0 sample had the highest cooking loss and K3 sample  
264 possessed the lowest cooking loss. While the effect of the concentration of butterfly pea extract  
265 resulted the lowest cooking loss values of T0 sample and the highest cooking loss values of T30  
266 sample. The cooking loss values of wet noodles ranged around 18 to 19 %.

267 Tensile strength, cooking loss and swelling index of wet noodles was clearly influenced by  
268 participation of components in dough formation, the interaction among glutelin, gliadin,  
269 glucomannan,  $\kappa$ -carrageenan and polyphenolic compounds resulted a three-dimensional network  
270 structure determined capability of resistance of the noodle strands to break and gel formation.  $\kappa$ -  
271 carrageenan is a high molecular weight hydrophilic polysaccharide composed hydrophobic 3,6-  
272 anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4)  
273 glycosidic linkages [58,59] that can bind water molecule to form gel. Glucomannan is soluble fiber  
274 with main chain  $\beta$ -1,4 linkage of D-glucose and D-mannose that can absorb water molecule around  
275 200 times [60] to form strong gel that increases viscosity and swelling index of dough [61]. Park and  
276 Baik [62] claimed that tensile strength of noodles is affected by gluten network formation. Huang  
277 et al. [55] also reported that  $\kappa$ -carrageenan can increase firmness and viscosity of samples because  
278 the water binding capacity of this hydrocolloid is very strong. Cui et al. [51] claimed that konjac  
279 glucomannan does not only stabilize the structure of gluten network but react free water molecule  
280 to form more stable of a three-dimensional networking structure, thus holding the rheological and  
281 tensile properties of dough.

282 The increasing of swelling index of dough is caused the capability of glucomannan to  
283 reduce pore size and increase the pore numbers with uniform size <sup>[63]</sup>. The synergistic interaction  
284 between these hydrocolloids and gluten protein results stronger, more elastic, and stable gel  
285 because of the association and lining up of the mannan molecules into the junction zones of  
286 helices<sup>[64]</sup>. The cross-linking and polymerization involving functional groups of gluten protein,  $\kappa$ -  
287 carrageenan and glucomannan determined binding force with each other. The stronger attraction  
288 between molecules composed cross-linking reduces the particles or molecules loss during  
289 cooking<sup>[64-66]</sup>. Stability of the network dimensional structure of protein was influenced by the  
290 interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in dough  
291 of wet noodles that determined tensile strength, swelling index and cooking loss of wet noodles.  
292 Schefer et al. <sup>[27]</sup> and Widyawati et al. <sup>[15]</sup> explained that phenolic compounds can disturb the  
293 interaction between protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to  
294 form a complex structure through many interactions, including hydrophobic, electrostatic, and Van  
295 der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly  
296 pea extract were interacted with  $\kappa$ -carrageenan, glucomannan, protein or polysaccharide and  
297 influenced complex network structure. The phenolic compounds can disrupt a three-dimensional  
298 networking of interaction among gluten protein,  $\kappa$ -carrageenan and glucomannan through  
299 aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of  
300 disulphide bridges to form of thiols radicals <sup>[65,66]</sup>. These compounds can form complexes with  
301 protein and hydrocolloids leading to structural and functional changes and influence gel formation  
302 though aggregation formation and disulphide bridges breakdown <sup>[26,27,67]</sup>.

303 Color of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction between  
304 the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with

305 increasing the ratio of composite flour and the concentration of butterfly pea extract. Most of color  
306 parameters values were lower than the control (K0T0, K1T0, K2T0, K3T0), except yellowness  
307 and chroma values of K2T0 and K3T0, whereas the increasing of amount of butterfly pea extract  
308 changed all color parameters. The ranging of  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $oh$  were about 44 to 67, -13 to 1,  
309 -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness and yellowness of wet noodles  
310 grew with going up the  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea  
311 flower extract. Chroma and hue of wet noodles decreased with increasing of  $\kappa$ -carrageenan  
312 proportion from T0 until T15, and then increased at T30. K2T30 treatment had the strongest blue  
313 color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -carrageenan in composite  
314 flour also supported water holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan  
315 was synergized with glucomannan to produce strong stable network that involved sulfhydryl  
316 groups. Tako and Konishi <sup>[68]</sup> reported that  $\kappa$ -carrageenan is capable to associate making polymer  
317 structure that involves intra- and intern molecular interaction, such as ionic bonding and  
318 electrostatic forces. The mechanism of making three-dimensional network structure that  
319 implicated all component of composite flour was very complicated because they involved polar  
320 and non-polar functional groups and many kinds of interaction of them. These were influenced  
321 water content and water activity of wet noodles that were impacted wet noodle color. The other  
322 cause of wet noodles was anthocyanin pigment from butterfly pea extract. Gamage et al. <sup>[69]</sup>  
323 reported that anthocyanin pigment of butterfly pea is delphinidin-3-glucoside having blue color.  
324 Increasing of extract concentration declined lightness, redness, yellowness and chroma as well as  
325 changed hue color from yellow to be green until blue color.

326 The effect of composite flour and butterfly pea extract on color was observed in chroma  
327 and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness,

328 but butterfly pea extract reduced the two parameters. Thanh et al. [70] and Padmawati et al. [71] also  
329 founded similarity of their research. Anthocyanin pigment of butterfly pea extract can be interacted  
330 with color of stinky lily and  $\kappa$ -carrageenan impacted color change of wet noodles. Thus, the sample  
331 T0 is yellow color, T15 is green color and T30 is blue color. Color intensity showed as chroma  
332 values of yellow values increased along with higher proportion of  $\kappa$ -carrageenan at the same  
333 concentration of butterfly pea extract, but the higher concentration of butterfly pea extract declined  
334 green and blue colors of wet noodles at the same proportion of composite flour. Wet noodle color  
335 also estimated to be influenced by the phenolic compound content which underwent  
336 polymerization or degradation during the heating proses. Widyawati et al. [28] reported that  
337 bioactive compounds in pluchea extract can change wet noodle color because of discoloration of  
338 pigment during cooking. K2T30 was wet noodles having strongest blue color due to different  
339 interaction of anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan that were  
340 capable to reduce intensity of blue color or chroma values.

341 **The content of phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) of wet**  
342 **noodles**

343 TPC, TFC and TAC were shown in Fig. 5. The TPC and TFC of wet noodles were  
344 significantly influenced by interaction between two parameters of the ratio of composite flour and  
345 the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and  
346 butterfly pea extract resulted the highest TPC and TFC. The K2T30 had the highest TPC and TFC  
347 as  $\sim 207$  mg GAE/kg dried noodles and  $\sim 57$  mg CE/kg dried noodles, respectively. While the  
348 TAC of wet noodles was only influenced by the concentration of butterfly pea extract, the increase  
349 in extract addition leading to an increase in TAC. The extract substitution at T30 was obtained  
350 about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles of TAC. Based on Pearson correlation,

351 TPC of wet noodles was strong and positive correlated with TFC at T0 treatment ( $r= 0.955$ ), T15  
352 treatment ( $r=0.946$ ), T30 ( $r=0.765$ ), while TPC of samples was weak and positive correlated with  
353 TAC at T0 treatment ( $r=0.153$ ) and T30 ( $r=0.067$ ), except the samples at T15 treatment had  
354 correlation coefficient  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated  
355 with quality properties and antioxidant activity (AOA). Dominant anthocyanin pigment from  
356 butterfly pea extract is delphinidin <sup>[72]</sup> around  $2.41$  mg/g samples <sup>[73]</sup> that has free more acyl groups  
357 and aglycone structure <sup>[74]</sup> and can be used as natural pigment. The addition of butterfly pea extract  
358 influenced the color of wet noodles. Anthocyanin is potential as antioxidant agent through free-  
359 radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway,  
360 and inflammatory cytokines signaling <sup>[75,76]</sup>. Nevertheless, butterfly pea extract also composes  
361 tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids,  
362 anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids,  
363 and flavonol glycosides (kaempferol, quercetin, myricetin, 6''-malonylstragalgin, phenylalanine,  
364 coumaroyl sucrose, tryptophan, and coumaroyl glucose) <sup>[20,21]</sup>, chlorogenic, gallic, p-coumaric  
365 caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids <sup>[74]</sup>, ternatin  
366 anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexen, 1-methyl-4(1-  
367 methylethylidene), hirsutene <sup>[77,78]</sup>, that contribute to have antioxidant activity <sup>[18,78]</sup>. *Clitoria*  
368 *ternatea* shows potential as antioxidant activity based on an antioxidant assays, such as 2,2-  
369 diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power  
370 (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen  
371 radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion  
372 chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6- sulphonic acid) (ABTS) radical  
373 scavenging and  $\text{Cu}^{2+}$  reducing power assays <sup>[78]</sup>. TPC and TFC of wet noodles increased along

374 with the higher proportion of glucomannan in composite flour and the higher concentration of  
375 butterfly pea extract. Zhou et al. [79] claimed that glucomannan in stinky lily has hydroxyl groups  
376 that can be reacted with Folin Ciocalteus's phenol reagent. Devaraj et al. [80] reported that 3,5-  
377 acetylalbulin is flavonoid compounds in glucomannan can be bound complexes with  $AlCl_3$ .

### 378 **Antioxidant activity of wet noodles**

379 The antioxidant activity (AOA) of wet noodles was determined using DPPH radical  
380 scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP) as shown in Fig. 5. The  
381 proportion of composite flour and concentration of butterfly pea extracts significantly affected the  
382 DPPH ( $p \leq 0.05$ ). The noodles had DPPH ranging from 3 to 48 mg GAE/kg dried noodles. The  
383 noodles including composite flour of K0 and K1 and without of butterfly pea extracts (K0T0 and  
384 K1T0) had lowest DPPH, while the samples containing composite flour K2 with butterfly pea  
385 extracts 30% (K2T30) had highest DPPH. Pearson correlation showed that TPC and TFC were  
386 strong and positive correlated with DPPH (Table 7). Correlated coefficient values ( $r$ ) between TPC  
387 and AOA at T0, T15 and T30 treatments were 0.893, 0.815, and 0.883, respectively. Whereas  $r$   
388 values between TFC and DPPH at T0 treatment were 0.883, at T15 treatment were 0.739, and at  
389 T30 treatment were 0.753. However, correlation coefficient values between TAC and AOA at T0,  
390 T15 and T30 treatments were 0.123, 0.127, and 0.194, respectively. Interaction among  
391 glucomannan, phenolic compounds, amylose, gliadin and glutelin in dough of wet noodles  
392 determined number and position of free hydroxyl groups of them that influenced TPC, TFC, and  
393 DPPH. Widyawati et al. [46] said that free radical inhibition activity and chelating agent of phenolic  
394 compounds depends on position of hydroxyl groups and conjugated double bond of phenolic  
395 structures. The values of TPC, TFC and DPPH increased with higher level of stinky lily flour and  
396  $\kappa$ -carrageenan proportion and butterfly pea extract significantly up to 18 and 2% (w/w)

397 glucomannan and  $\kappa$ -carrageenan and 15% (w/w) extract, but the using of 17 and 3% (w/w)  
398 glucomannan and  $\kappa$ -carrageenan and 30% (w/w) extract showed a significant decrease. This  
399 showed that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17:3% (w/w) was able to  
400 reduce free hydroxyl groups which had the potential as electron or hydrogen donors in testing  
401 TPC, TFC and DPPH.

402 FRAP of wet noodles was significantly influenced by the interaction of two parameters of  
403 the proportion of composite flour and concentration of butterfly pea extracts ( $p \leq 5\%$ ). FRAP was  
404 used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ion to be  $\text{Fe}^{2+}$  ion. FRAP  
405 capability of wet noodles was lower than DPPH ranging 0.01 to 0.03 mg GAE/kg dried noodles.  
406 The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had lowest FRAP, while the  
407 samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest  
408 FRAP. Pearson correlation values showed that TPC dan TFC at T0 and T30 treatments had strong  
409 and positive correlated to FRAP activity, but T15 treatment possessed weak and positive  
410 correlation (Table 7). Correlation coefficient (r) values of TAC at T0 treatment was weak and  
411 positive correlated to FRAP samples, but r values at T15 and T30 treatments owned weak and  
412 negative correlation (Table 3). The correlation between DPPH and FRAP activities was obtained  
413 that DPPH method was highly correlated with FRAP method at T0 and T30 treatments and lowly  
414 correlated at T15 treatment (Table 3). Based on DPPH and FRAP methods showed that capability  
415 of wet noodles to scavenge free radical was higher than them to reduce ferric ion. It proved that  
416 bioactive compounds of wet noodles were more potential as free radical scavengers or hydrogen  
417 donors than as donor electron. Compounds that have capability to reducing power can act as  
418 primary and secondary antioxidant [81,82]. Poli et al. [83] said that bioactive compounds acted as  
419 DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless,



420 Suhendy et al. <sup>[84]</sup> claimed that a secondary antioxidant is natural antioxidant that has capability to  
421 reduce ferric ion (FRAP). Based on AOA assay, the results showed that phenolic compounds  
422 indicated strong and positive correlation with flavonoid compounds because of they are major  
423 phenolic compounds that are potential as antioxidant activities pass through highly effective  
424 scavenger of various free radicals. The effectivity of flavonoid compounds to inhibit free radicals  
425 and chelating agents is influenced by number and position of hydrogen groups and conjugated  
426 diene at A, B, and C rings <sup>[85-87]</sup>. Previous studies have proven that TPC and TFC exhibit significant  
427 contributor to scavenge free radicals <sup>[88-90]</sup>. However, TAC showed a weak correlation with TFC,  
428 TPC or AOA, although Choi et al. <sup>[89]</sup> stated that TPC and anthocyanins have a significant and  
429 positive correlation with AOA but anthocyanins were insignificantly correlated with AOA.  
430 Different structure of anthocyanins in samples determines AOA. Polymer anthocyanins or  
431 anthocyanin complexed with other molecules assign capability of them to electron or hydrogen  
432 donors. Martin et al. <sup>[91]</sup> informed that the anthocyanins are major groups of phenolic pigments  
433 that are an essential antioxidant activity depend on a steric hindrance of their chemical structure,  
434 such as number and position of hydroxyl groups and the conjugated double bonds, as well as the  
435 presence of electron in the structural ring. However, TPC and TFC at T0 and T30 treatments were  
436 highly and positive correlated with FRAP assay due to the role of phenolic compounds involved  
437 reducing power that contributed them to donor electron. Paddayappa et al. <sup>[82]</sup> reported that the  
438 phenolic compounds are capable to embroiled redox activities with action as hydrogen donor and  
439 reducing agents. The weakly relationship between TPC or TFC or DPPH and FRAP in the T15  
440 treatment suggested that there was an interaction between the functional groups in the benzene  
441 ring in phenolic and flavonoid compounds and the functional groups in components in composite  
442 flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

## 443 **Sensory Evaluation**

444           Sensory properties of wet noodles based on hedonic method, showed that composite flour  
445 and butterfly pea extract additions significantly influenced color, aroma, taste, and texture  
446 preferences ( $p \leq 0.05$ ) (Table 4). The preference values of color, aroma, taste, and texture attributes  
447 of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. The using of butterfly  
448 pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet  
449 noodles. Anthocyanin of butterfly pea extract gave different intensity of wet noodle's color that  
450 resulted color degradation from yellow, green until blue color impacted color preference of wet  
451 noodles. Nugroho et al. <sup>[48]</sup> also informed that addition of butterfly pea extract upgraded preference  
452 of panelist to dried noodles. Aroma of wet noodles was also affected by two parameters of  
453 treatments, the results showed that the higher proportion of stinky lily caused the stronger musty  
454 smell of wet noodles. Utami et al. <sup>[92]</sup> claimed that oxalic acid of stinky lily flour contributes to  
455 odor of rice paper. Therefore, a high proportion of k-carrageenan can reduce the proportion of  
456 stink lily flour, thereby increasing the panelist's preference for aroma. Sumartini and Putri <sup>[93]</sup>  
457 informed that panelist is more like noodles substituted the higher  $\kappa$ -carrageenan. Kurniadi et al.  
458 <sup>[94]</sup> and Widyawati et al. <sup>[15]</sup> said that  $\kappa$ -carrageenan is odorless material which doesn't result aroma  
459 of wet noodles. Neda et al. <sup>[77]</sup> added that volatile compounds of butterfly pea extract can mask  
460 musty smell of stinky lily flour, such as pentanal and mome inositol, Padmawati et al. <sup>[71]</sup> informed  
461 that they can gave sweet and sharp aroma. Taste preference of panelist to wet noodles without  
462 butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin <sup>[95]</sup> due to Maillard  
463 reaction of stinky lily flour processing. Nevertheless, using of butterfly pea extract at higher  
464 concentration of wet noodles increased bitter taste related to tannin compounds in this flower, this  
465 is supported by Hasby et al. <sup>[96]</sup> and Handayani and Kumalasari <sup>[97]</sup>. Effect of composite flour

466 proportion and butterfly pea extract also appeared to texture preference of wet noodles. Panelist  
467 was likely wet noodles that was not break up easily that K3T0 samples were chewy and elastic wet  
468 noodles, this was supported by tensile strength of wet noodles because of the different  
469 concentration of butterfly pea extract. The addition butterfly pea extract at higher concentration  
470 resulted sticky, break easy and less chewy wet noodles <sup>[26,27,85,97]</sup> due to competition among  
471 phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with  
472 water molecules to form gel <sup>[98]</sup>. Based on index effectiveness test, the noodles including composite  
473 flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment with total score of  
474 1.0504.

#### 475 **Conclusions**

476 Using of composite flour containing wheat flour, stinky lily flour and  $\kappa$ -carrageenan and  
477 butterfly pea extract influenced quality, bioactive compounds, antioxidant activity, and sensory  
478 properties of wet noodles. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -  
479 carrageenan and phenolic compounds determined a three-dimensional network structure that  
480 impacted moisture content, water activity, tensile strength, color, cooking loss, and swelling index,  
481 bioactive content, antioxidant activity, and sensory properties. The higher concentration of  
482 hydrocolloid addition caused increasing of water content and swelling index and decreasing of  
483 water activity and cooking loss. Addition of butterfly pea extract improved color, bioactive content  
484 and antioxidant activity and repaired panelist preference of wet noodles. Glucomannan of stinky  
485 lily flour and bioactive compounds of butterfly pea extract were able to increase the functional  
486 value of resulting wet noodles.

487

488

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**492 Conflict of Interest**

493 The authors declare no conflict of interest

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815 Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

816 Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink  
817 lily flour:  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan =  
818 80:18:2 (%w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 =  
819 concentration of the butterfly pea extract = 0%. T15= concentration of the butterfly pea extract =  
820 15%. T30 = concentration of the butterfly pea extract = 30%.

Table 2. Quality properties of wet noodles at the various ratio of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: Effect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles.

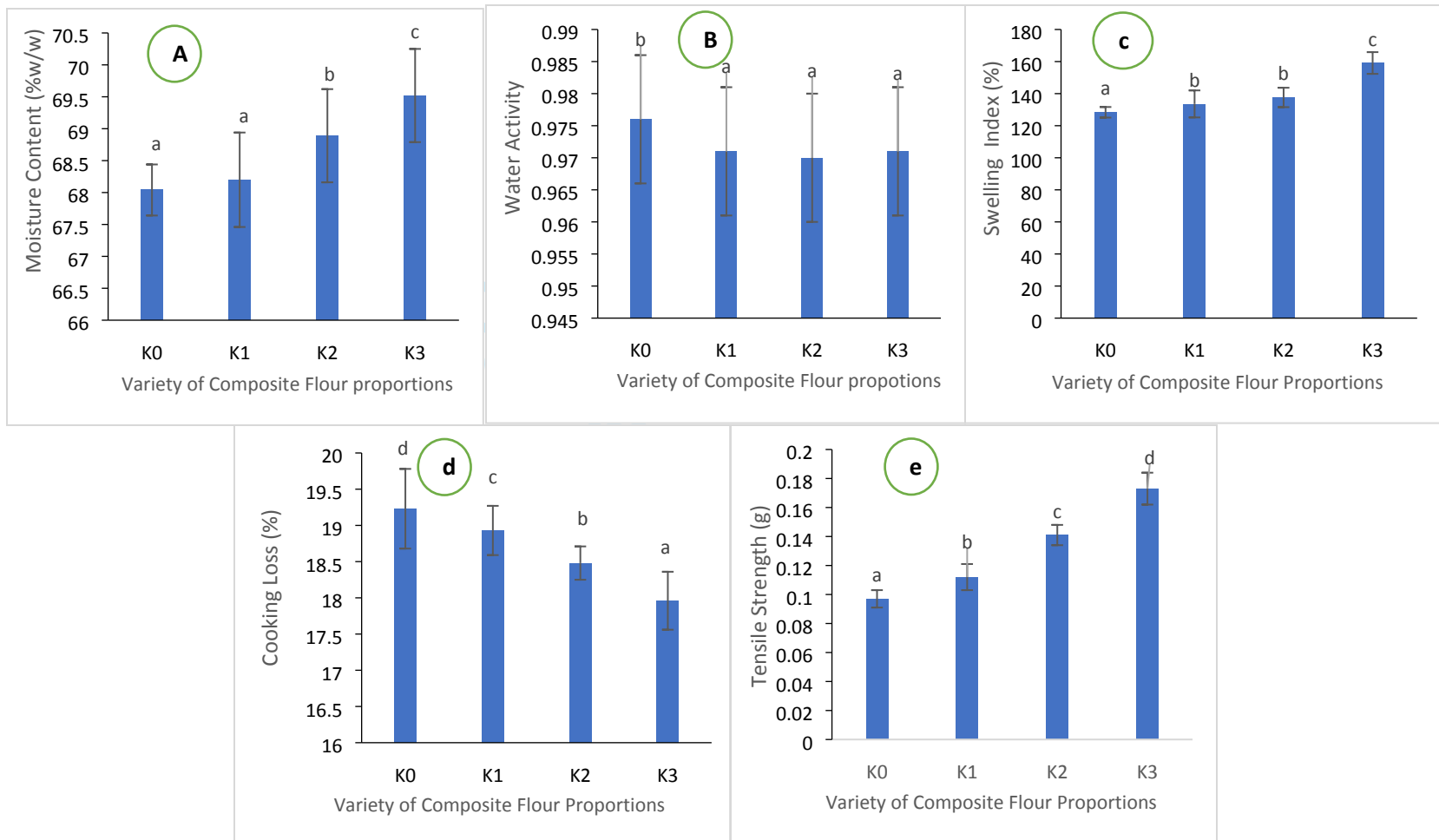


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

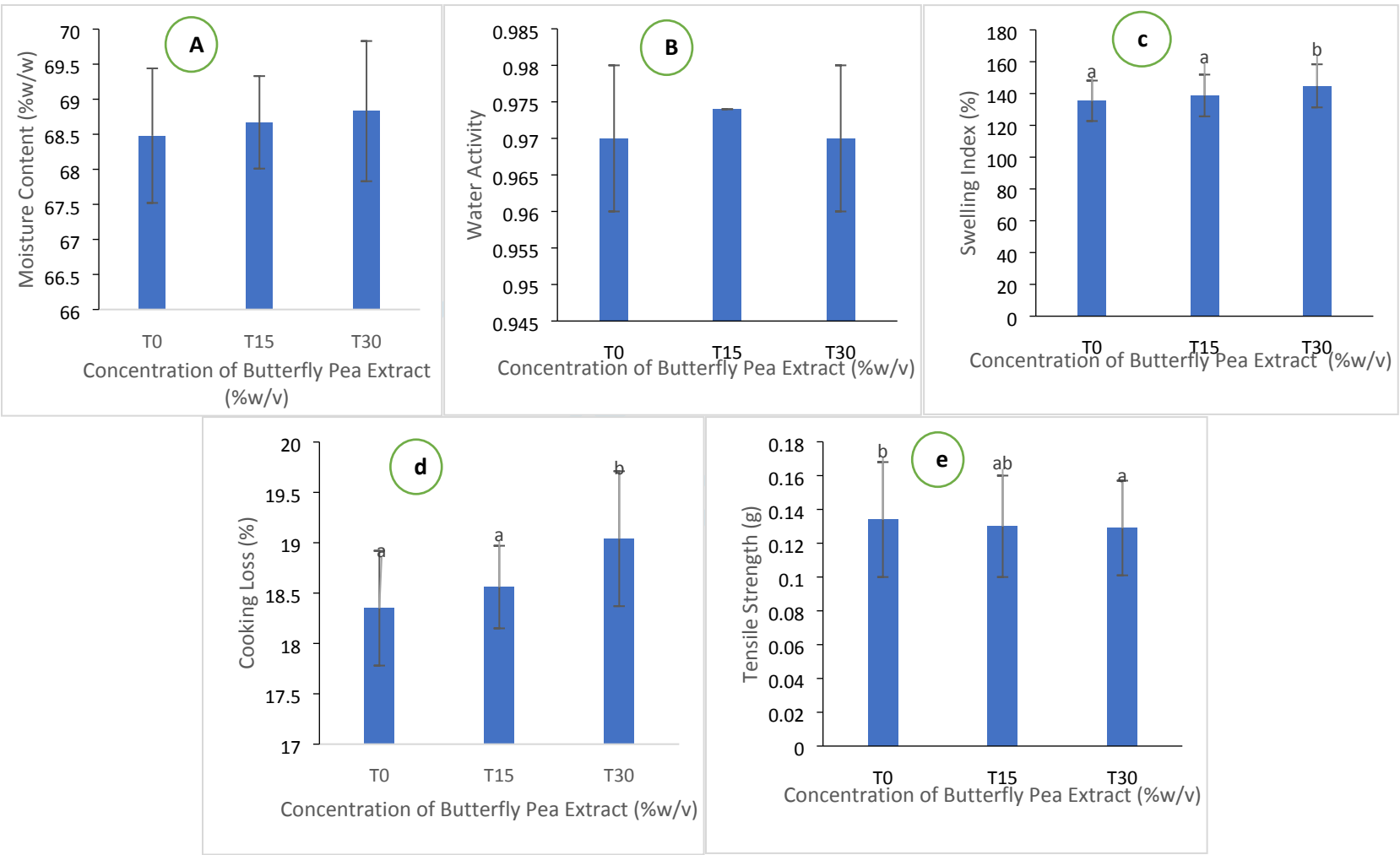


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

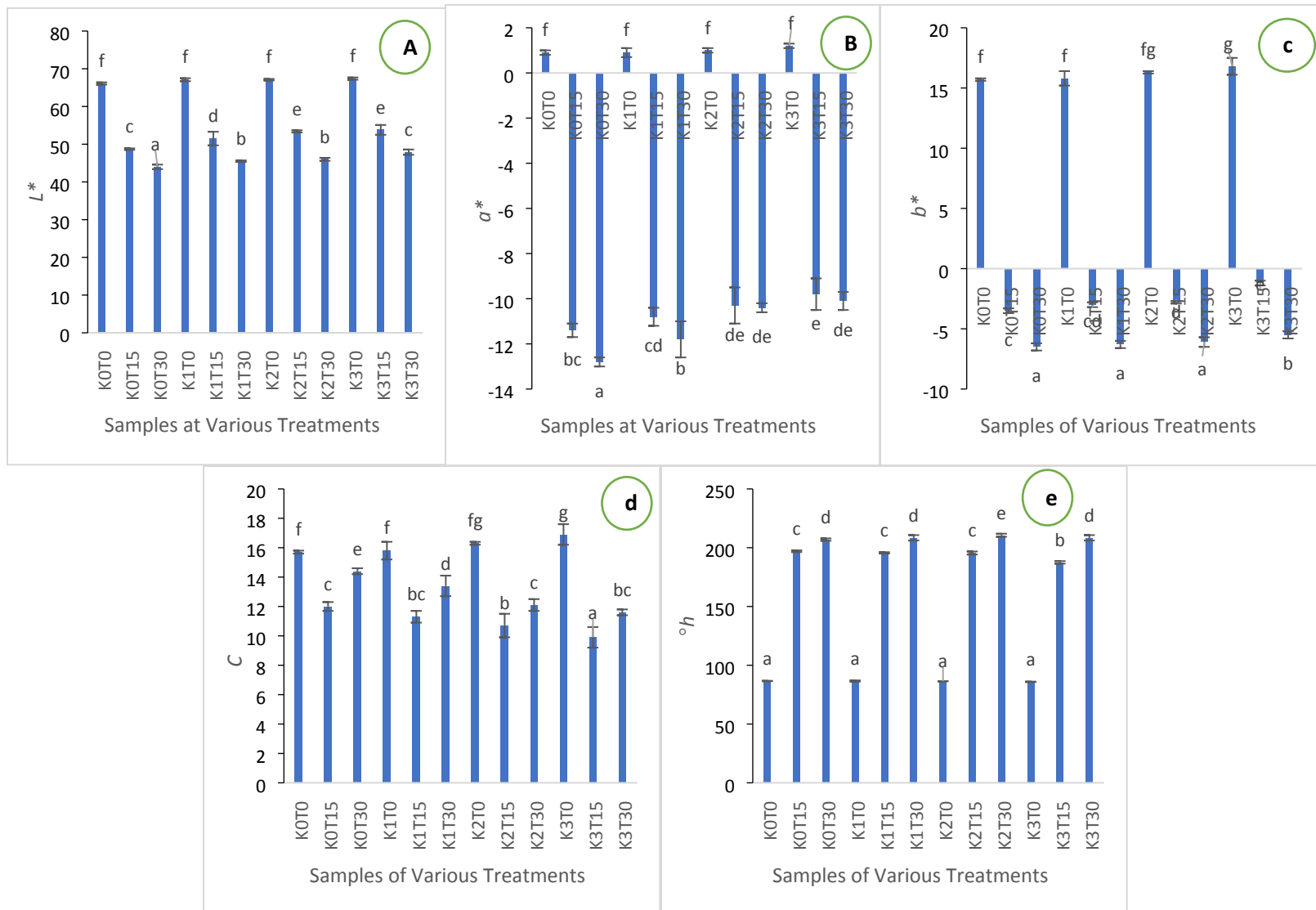


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .



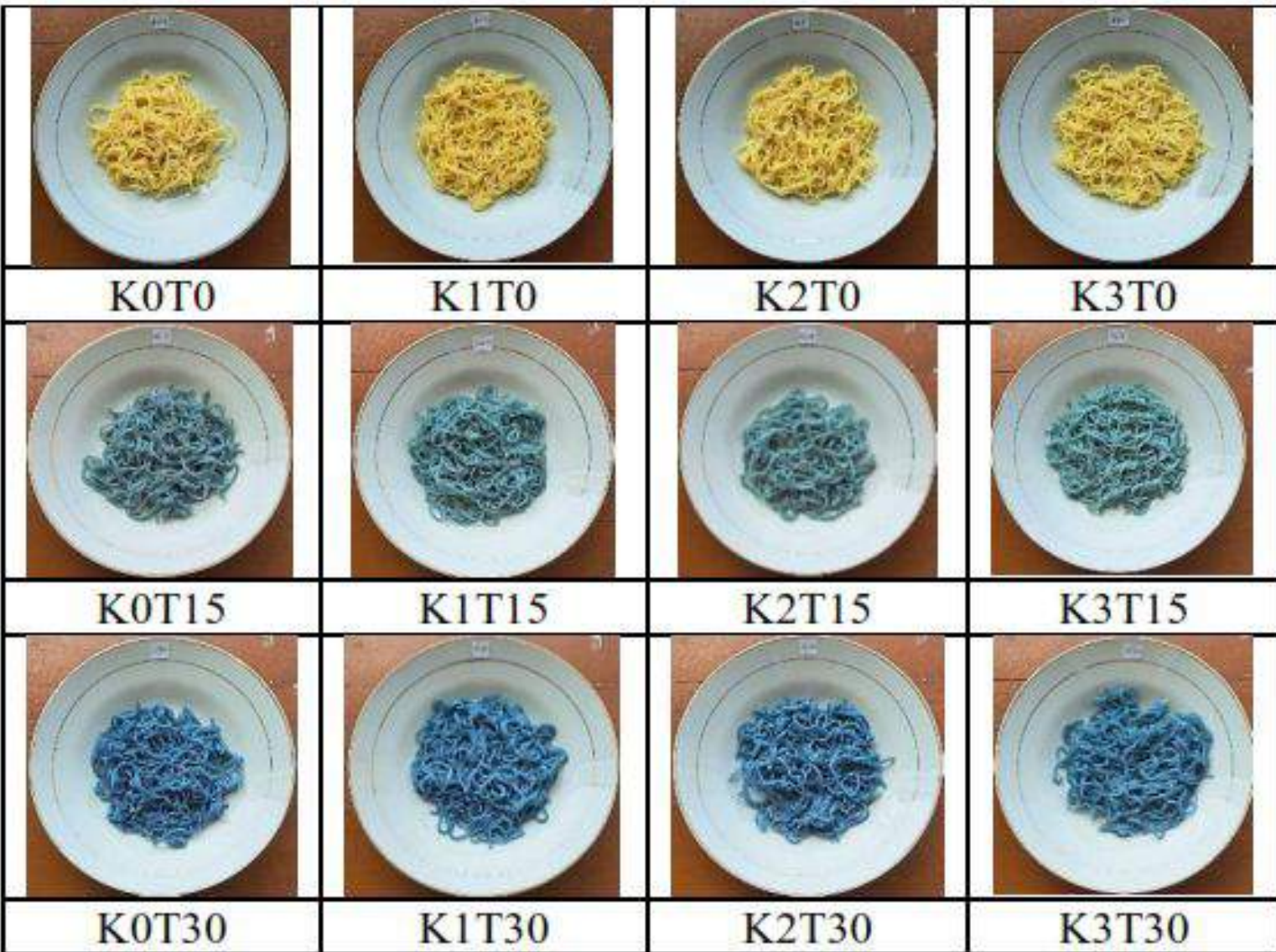


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract



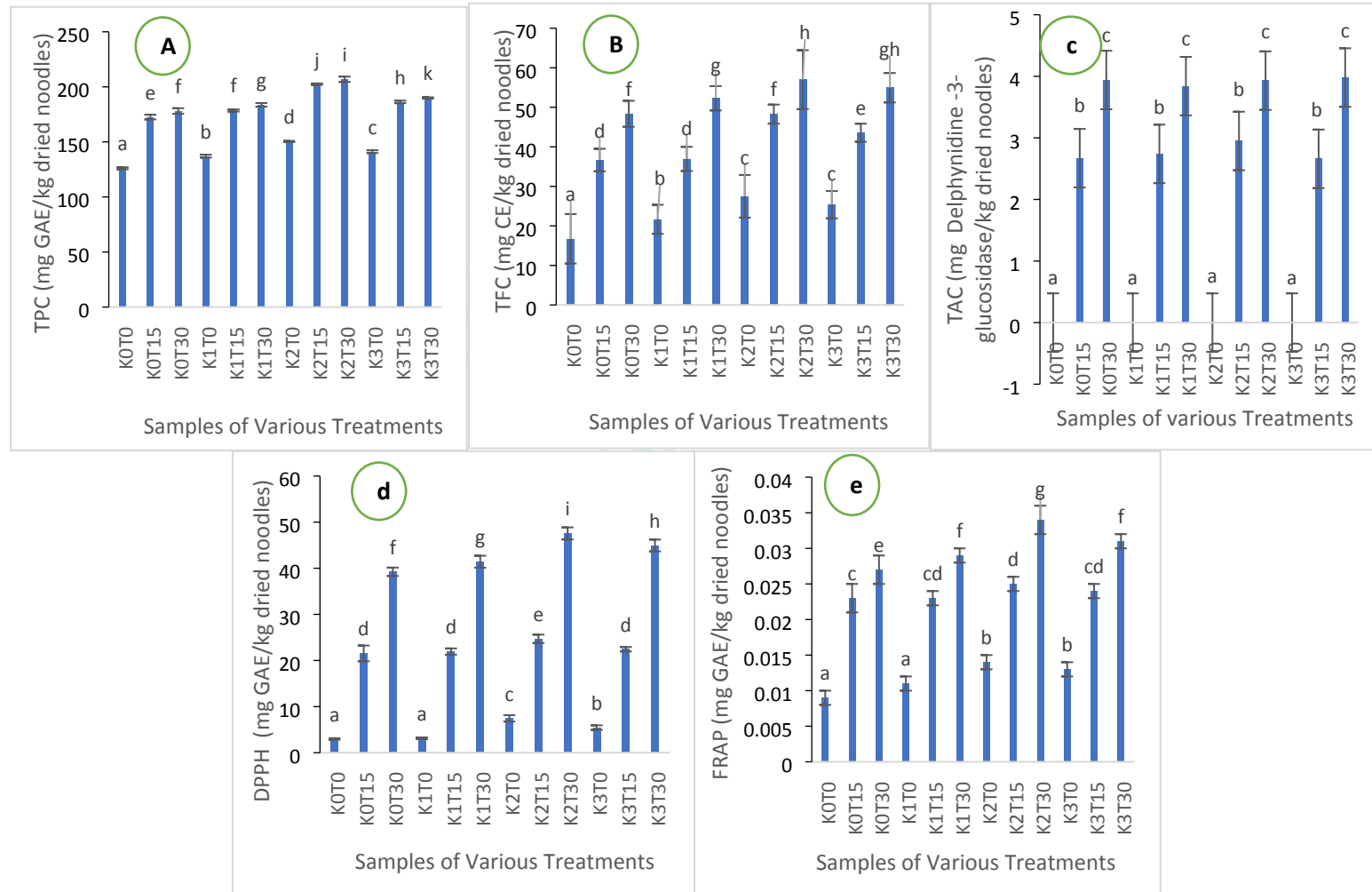


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

Table 4. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

For Review Only

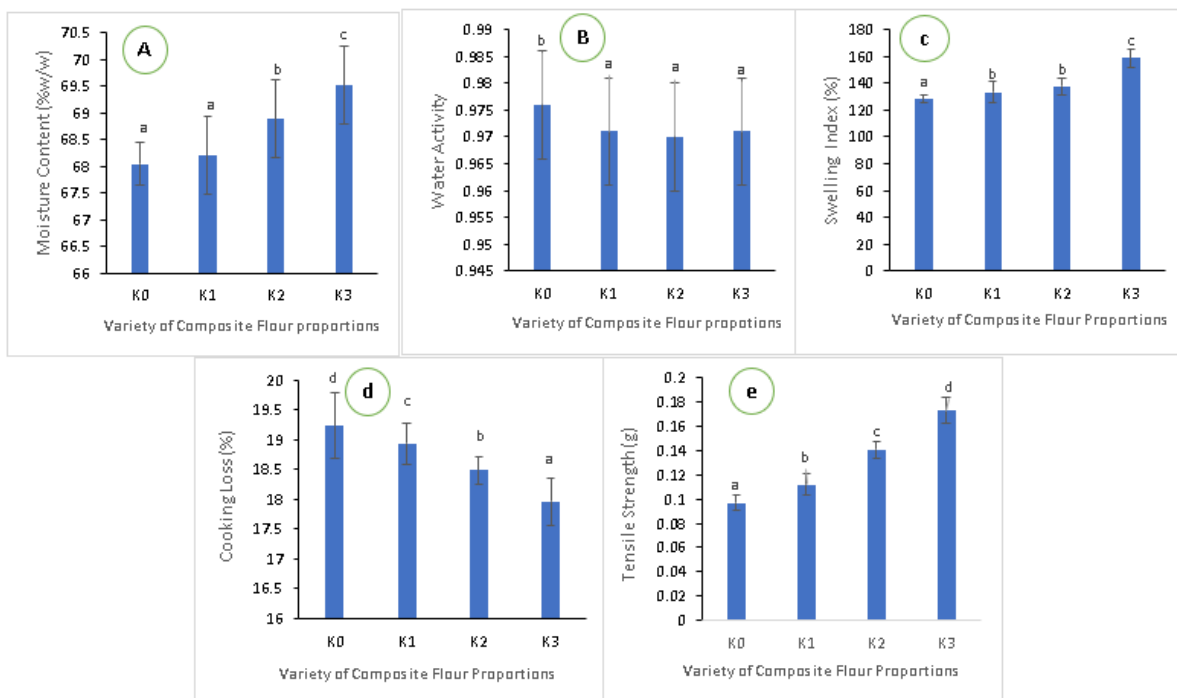


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

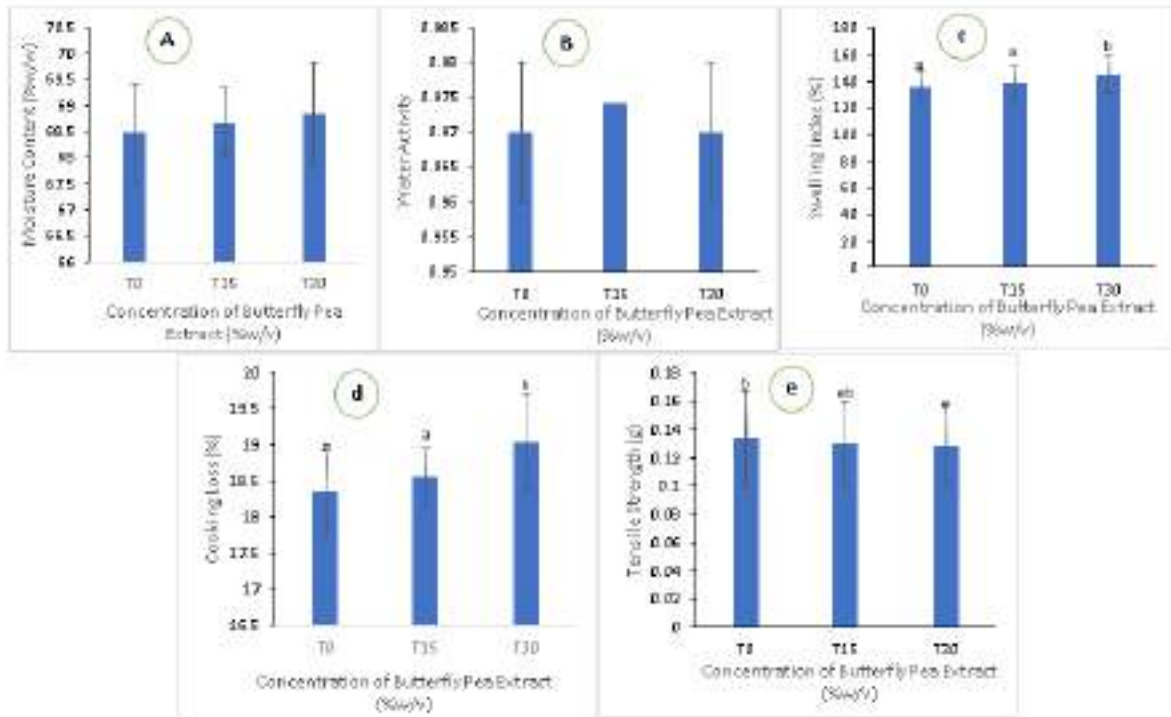


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

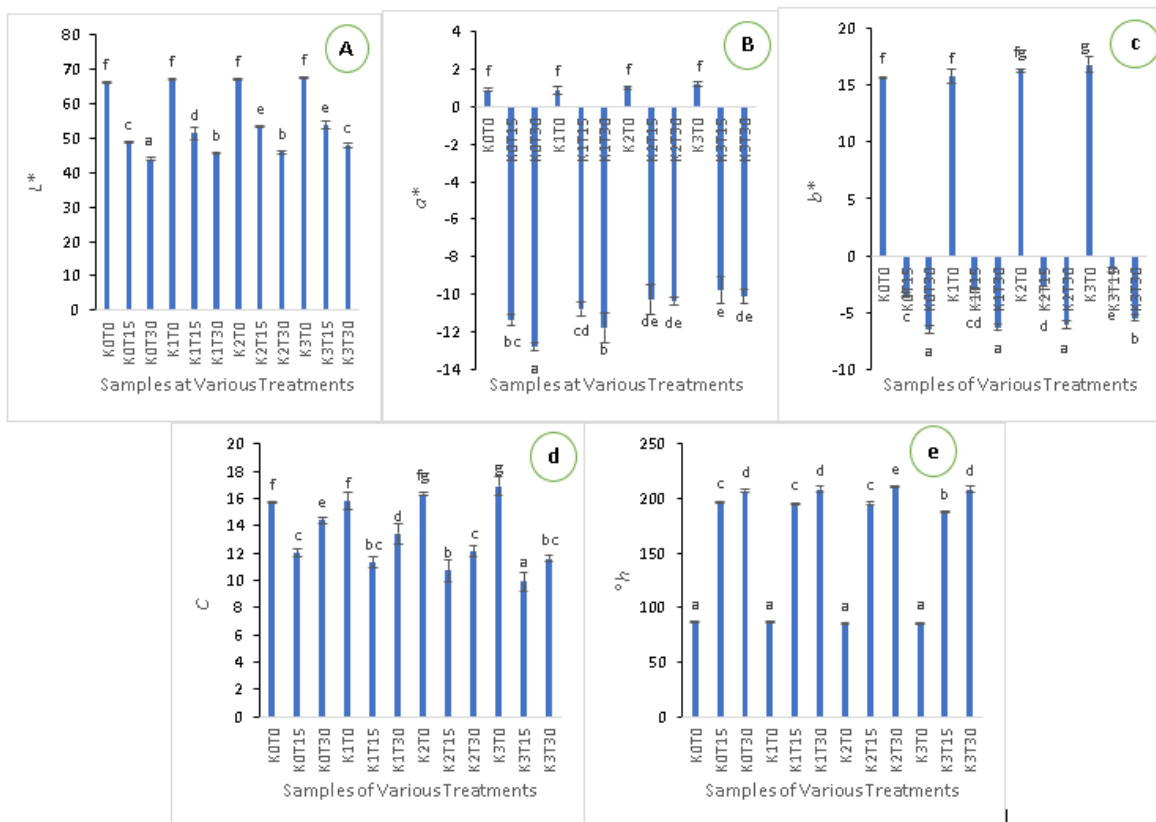


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness*/ $L^*$ , b. *Redness*/ $a^*$ , c. *Yellowness*/ $b^*$ , d. *Chroma*/ $C$ , e. *Hue*/ $h^\circ$ ). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

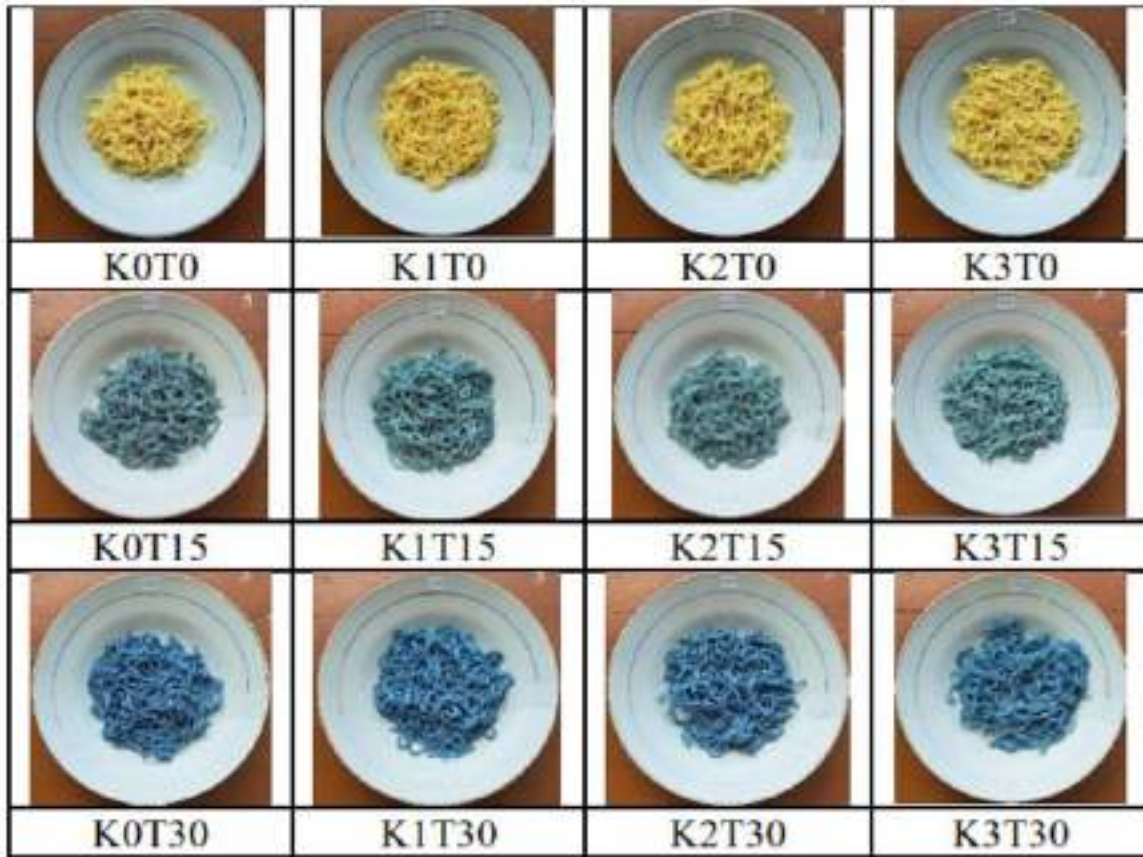


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract.

Only



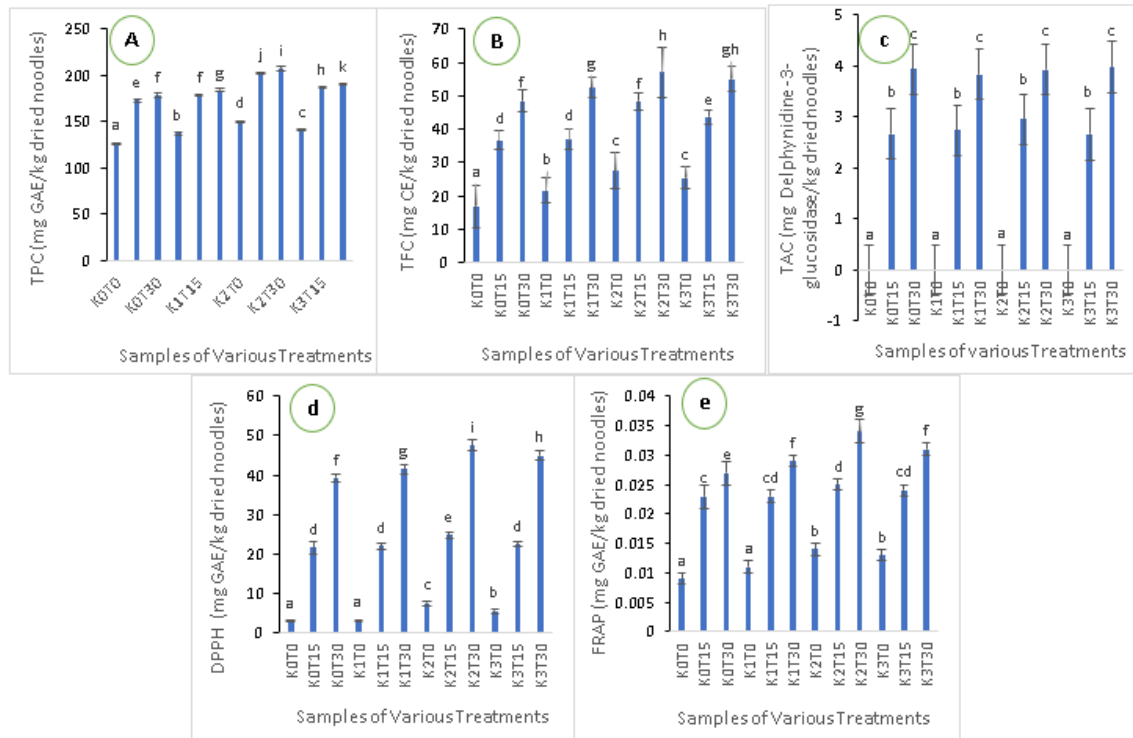


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

Table 2. Quality properties of wet noodles at the various ratio of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: Effect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles.

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

Table 4. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

## 2. First Review: Major Revision (7-10-2023)

- Correspondence
- Decision Letter
- Document

# Beverage Plant Research

## Decision Letter (BPR-S2023-0041)

**From:** bpr@maxapress.com

**To:** paini@ukwms.ac.id

**CC:**

**Subject:** Beverage Plant Research - Decision on Manuscript ID BPR-S2023-0041

**Body:** 07-Oct-2023

Dear Dr. Widyawati:

Thank you for submitting to the Beverage Plant Research.

Manuscript ID BPR-S2023-0041 entitled "Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties and antioxidant activity of wet noodles" has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter.

The reviewer(s) and I have concerns that will require a major revision of your manuscript. Please evaluate the comments carefully and if you feel you can address the issues, we would welcome a revision.

To revise your manuscript, log into <https://mc03.manuscriptcentral.com/bevpr> and enter your Author Center, where you will find your manuscript title listed under "Manuscripts with Decisions." Under "Actions," click on "Create a Revision." Your manuscript number has been appended to denote a revision.

You may also click the below link to start the revision process (or continue the process if you have already started your revision) for your manuscript. If you use the below link you will not be required to login to ScholarOne Manuscripts.

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[https://mc03.manuscriptcentral.com/bevpr?URL\\_MASK=8bf43a576aab434db71a2006d785effb](https://mc03.manuscriptcentral.com/bevpr?URL_MASK=8bf43a576aab434db71a2006d785effb)

You will be unable to make your revisions to the originally submitted version of the manuscript. Instead, revise your manuscript using a word processing program and save it on your computer. Please also highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or colored text.

Once the revised manuscript is prepared, you can upload it and submit it through your Author Center.

When submitting your revised manuscript, you will be able to respond to the comments made by the reviewer(s) in the space provided. You can use this space to document any changes you make to the original manuscript. In order to expedite the processing of the revised manuscript, please be as specific as possible in your response to the reviewer(s).

**IMPORTANT:** Your original files are available to you when you upload your revised manuscript. Please delete any redundant files before completing the submission.

For the revised manuscript, we suggest you submit the manuscript text, tables and figures, and supplementary files separately. Your submission should include:

- A rebuttal letter;
- Marked-up version of the manuscript (Word) with no figures;
- Clean (non-highlighted) version of the manuscript;
- Figures with a resolution of 300 dpi or above are expected;
- Supplementary files (Word or Excel) are anticipated.

Because we are trying to facilitate timely publication of manuscripts submitted to the Beverage Plant Research, we recommend a 4-week deadline for the submission of revised manuscript (Please Note: The exact cutoff time is 00:00 EST on 06-Nov-2023). If submitting your revision within a reasonable timeframe is not feasible for you, feel free to reach out to us to request an

extension for the submission deadline.

Once again, thank you for submitting your manuscript to the Beverage Plant Research and I look forward to receiving your revision.

Sincerely,  
Prof. Zongmao Chen  
Editor-in-Chief  
Beverage Plant Research

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author

Adding butterfly pea flower extract was found significantly influence the quality and antioxidant activity of wet noodles. This study help improve the quality of wet noodles. However, there are many points needed to be improved.

1. The English should be improved.
2. Line 115, 117 and 120. There should be a room between the number and the temperature unit.
3. Line 125, 131, 141 & 148. The number should not be as the first word of a sentence.
4. Line 477. There should be a 'the' in front of quality.
5. The number of the references should be reduced. There are too many references.
6. Table 1 should be revised as three-wire table.
7. Difference significance analysis should be added in the Table 2.
8. The figures should be aestheticized.

Reviewer: 2


Comments to the Author

I reviewed the manuscript entitled, Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties and antioxidant activity of wet noodles. Overall, the manuscript is well organized along with suitable literature comparison. While the research method is traditional, and the whole study is not deep enough.

Comments

1. Title should be further revised, like "Effect of butterfly pea flower extract to ...of wet noodles with various composite flour proportions."
2. Figure 2, what is the x axis means? What is the flour composition of these groups? Did T0, T15, and T30 combine with the same composite flour or different ones? Why didn't they show like other figures? 12 groups? Please clearly indicate it.
3. Please define line 51 the abbreviation DPPH, and please check other abbreviations.
4. Line 101-111, it's better for the authors to describe briefly how the butterfly pea extract add to the flour, not just displayed in Table 1. Is it dry extract or solution? How much added?
5. For all figures, and Table 2-4, there are no explanation of the treatment groups name (abbreviations) in the figure legend.
6. Color analysis: what is the control?
7. Conclusion: authors have written the summary of results and discussion. Explain how the information generated from this research will be helpful to scientific community and food industry.
8. It maybe better for the authors to further describe the interactions among phytochemical compounds and ingredients of wet noodles base composite flour with the molecular structure analysis, like the FTIR, SEM.

**Date Sent:** 07-Oct-2023

 Close Window



1 **Effect of ~~composite flour proportion and~~ butterfly pea (*Clitoria ternatea*) flower extract ~~to~~**  
2 **~~on~~ qualities, sensory properties, and antioxidant ~~activit~~activity of wet noodles ~~with various~~**  
3 **composite flour proportions**

4  
5 Painsi Sri Widyawati\*<sup>1)</sup>, Thomas Indarto Putut Suseno<sup>1)</sup>, Felicia Ivana<sup>1)</sup>, Evelyne Natania<sup>1)</sup>, Sutee  
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7 <sup>1)</sup>Food Technology Study Program, Faculty of Agricultural Technology-Faculty, Widya Mandala  
8 Surabaya Catholic University, Dinoyo Street Number 42-44, Surabaya, Indonesia 60265

9 <sup>2)</sup>College of Maritime Studies and Management, Chiaaing Mai University, Samut Sakhon ~~Samut~~  
10 Sakhon 74000, Thailand

11 Correspondence email: [paini@ukwms.ac.id](mailto:paini@ukwms.ac.id)

12  
13 **Abstract**

14 The ~~improving-improvement~~ of wet ~~noodles-noodles'~~ qualities, sensory, and functional  
15 properties ~~were-was done-made~~ by using the composite flour base added with the butterfly pea  
16 flower extract. The composite flour ~~of-consisted of~~ wheat flour ~~and~~ -stink lily flour, and  $\kappa$ -  
17 carrageenan at ~~various-ratios ratio~~ of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3(K3)  
18 (% w/w) was used with the concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30)  
19 (% w/v). The research employed a randomized block design with ~~two2~~ factors, namely the  
20 composite flour and the concentration of butterfly pea flower extract, ~~that-and~~ resulted in 12  
21 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30,  
22 K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract  
23 ~~were~~-significantly affected ~~the-the~~ color profile, sensory properties, bioactive compounds, and  
24 antioxidant activities of wet noodles. However, each factor ~~also had~~-significantly influenced ~~of~~  
25 the physical properties ~~from-of~~ wet noodles, such as moisture content, water activity, tensile  
26 strength, swelling index, and cooking loss. The using of  $\kappa$ -carrageenan up to 3% (w/w) in  
27 ~~composite flour~~the mixture increased moisture content, swelling index, and tensile strength but  
28 reduced water activity and cooking loss.- K3T30 treatment with composite flour of wheat flour-  
29 stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) ~~was-had~~ the best-highest consumer  
30 acceptance based on hedonic sensory score.

31 **Keywords:** composite flour, butterfly pea flower, quality, sensory, wet noodles

32

33 **Introduction**

34 Composite flour is a mixture of ~~flour and~~ several types of flour ~~from other ingredients,~~  
35 ~~which~~ usually ~~come composed offrom~~ several types of carbohydrate sources (tubers, legumes,  
36 cereals) with or without wheat flour <sup>[1,2]</sup>. The composite flour is made to obtain suitable material  
37 characteristics for the desired processed product ~~to resultwith~~ certain functional properties <sup>[3]</sup>. The  
38 use of composite flour in wet noodles has been widely carried out to increase ~~the-its~~ functional  
39 values and ~~set theseveral characteristics, including~~ physical, chemical, and sensory ~~quality of the~~  
40 ~~wet noodlesproperties~~. Siddeeg et al.<sup>[4]</sup> ~~uses-used~~ wheat-sorghum-guar flour and wheat-millet-  
41 guar flour to improve the acceptability of wet noodles. Efendi et al.<sup>[5]</sup> ~~informed-stated~~ that potato  
42 starch and tapioca flour at a ratio of 50:50 (% w/w) can ~~update-enhance~~ the functional values of  
43 wet noodles. Dhull & Sandhu<sup>[6]</sup> claimed that noodles made from ~~a blend of fenugreek flour up to~~  
44 ~~7% with~~ wheat flour blended with fenugreek flour for up to 7 % ~~can~~ produced a good texture and  
45 a high consumer acceptance. Park et al.<sup>[7]</sup> ~~utilizes-utilized~~ the blended ratio of purple-colored  
46 wheat bran to increase wet noodles' quality and antioxidant activity ~~of wet noodles~~.

47 ~~Previous-A previous~~ study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
48 composited with wheat flour to increase the functional values of noodles by increasing the  
49 biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and  
50 prolonging gastric emptying time<sup>[8,9]</sup>. However, adding ~~of~~ stink lily flour ~~in-to~~ base noodles flour  
51 ~~had-resulted in wet noodles' limited elasticity and tensile strengthlimited on-elasticity and tensile~~  
52 ~~strength of wet noodles~~<sup>[10,11]</sup>. ~~ThenTherefore~~, the κ-carrageenan was ~~added-introduced~~ to improve  
53 the texture properties of wet noodles. Those components ~~were-a collaborates~~ collaborated with  
54 glucomannan to form ~~eross-linking~~ cross-linking with glutenin and gliadin by inter-~~n~~ and intra-

55 molecular bonds, ~~leading to improving~~ improving of noodle texture <sup>[12-14]</sup>. Widyawati et al. <sup>[15]</sup>  
56 explained that using ~~of~~ the composite flour ~~consisting~~ consisted of wheat flour, stink lily flour, and  
57  $\kappa$ -carrageenan can ~~look up~~ improve the swelling index, total phenolic content (TPC), total  
58 flavonoid content (TFC), ~~and~~ and 2,2-diphenyl-1-picrylhydrazyl DPPH free radical scavenging  
59 activity (DPPH), which ~~that~~ influences ~~an~~ the effectivity of bioactive compounds ~~on~~ in the  
60 composite flour ~~as that serve as~~ antioxidant sources of wet noodles. Therefore, other ingredients  
61 containing phenolic compounds can be added to increase composite flour's functional values as a  
62 source of antioxidants ~~Therefore, addition of the other ingredient enriched phenolic compounds is~~  
63 ~~done to increase functional values of composite flour as antioxidant~~. Czajkowska-González et al.  
64 <sup>[16]</sup> ~~informed~~ mentioned that ~~elaborate~~ incorporating of ~~natural antioxidant sources enriched~~  
65 phenolic ~~compounds~~ antioxidants from natural sources can improve the functional values of bread.  
66 Widyawati et al. <sup>[15]</sup> ~~has~~ added pluchea extract to increase the TPC, TFC, and DPPH ~~free radical~~  
67 ~~scavenging activity~~ of wet noodles; ~~but~~ however, this resulted in an unattractive ~~the weakness of~~  
68 wet noodle color. Therefore, it is necessary to incorporate other ingredients ~~is not attractive that~~  
69 ~~it is necessary to look for other ingredients to enhance,~~ the wet noodles' color profile and their  
70 functional properties, one of which is the butterfly pea flower.

71 Butterfly pea (*Clitoria ternatea*) is ~~a~~ herb plant from the, Fabaceae family with, ~~having~~  
72 various flower colors ~~flower~~, such as purple, blue, pink, and white <sup>[17]</sup>. This flower has  
73 phytochemical compounds ~~which that are~~ benefit as antioxidant sources <sup>[18,19]</sup>, including  
74 anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids,  
75 anthraquinones, sterols, alkaloids, and flavonol glycosides <sup>[20,21]</sup>. Anthocyanins of the butterfly pea  
76 flower has been used as natural color ants in many food products <sup>[22,23]</sup>, one of them is wet noodles  
77 <sup>[24,25]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the

78 interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-  
79 groups, double bonds (in the side chains), and the benzene rings [26]. This interaction involves their  
80 formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-  
81 hydrophobic properties and protein digestibility. This interaction involves covalent and non-  
82 covalent bonds of them which were influenced pH and determined hydrophilic-hydrophobic  
83 properties and protein digestibility [27]. A previous study has proven that the use of phenolic  
84 compounds from plant extracts, such as pluchea leaf [15,28], gendarussa leaf (*Justicia gendarussa*  
85 Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31] establishes contributes to the quality,  
86 bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiao et al. [25]  
87 has utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles,  
88 resulting in higher total anthocyanin, polyphenol, and DPPH scavenging activity and ferric  
89 reducing antioxidant power (FRAP) than the control samples. This extract also improved the color  
90 preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until  
91 now, the application of water extract of butterfly pea flowers in wet noodles has been commercially  
92 produced, but the interactions among phytochemical compounds and ingredients of wet noodles  
93 base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated.  
94 Therefore, the current study aimed to determine the effect of composite flour and butterfly pea  
95 flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory  
96 properties. utilized natural color of butterfly pea flower extract to make wet noodles base wheat  
97 flour that results the higher total anthocyanin, polyphenol, DPPH scavenging activity and reducing  
98 power than the control samples and the use of this extract can improve color preference and reduce  
99 the cutting force, tensile strength, and extensibility of cooked noodles. Until now, the application  
100 of water extract of butterfly pea flowers in wet noodles has been commercially produced but the

101 ~~interactions among phytochemical compounds and ingredients of wet noodles base composite~~  
102 ~~flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) has not been studied. Therefore, the study~~  
103 ~~was conducted to decide the effect of composite flour and butterfly pea flower extract to quality,~~  
104 ~~bioactive content, antioxidant activity, and sensory properties of wet noodles.~~

## 105 **Materials and Methods**

### 106 **Raw materials and preparation**

107 Butterfly pea flowers ~~were~~ obtained from Penjaringan Sari garden, Wonorejo, Rungkut,  
108 Surabaya, Indonesia. The flowers ~~were~~ sorted, washed, dried ~~by~~ under open sunlight, powdered  
109 using ~~a~~ blender (Philips HR2116, PT Philips, Netherlands) for 3 min, ~~and~~ sieved using a sieve  
110 shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group,  
111 China). The water extract of butterfly pea flower was obtained using ~~a~~ hot water extraction at 95  
112 °C for 3 min to get three concentrations of butterfly pea extract: ~~of~~ 0 (T1), 15 (T15), and 30 (T30)  
113 (% w/v). The ~~three-compositethree-composite~~ flours proportions were prepared ~~with~~ ~~aby~~ mixing  
114 ~~of~~ wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka  
115 Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis,  
116 MO, USA). Indonesia) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (%  
117 w/w).

### 118 **Chemical and reagents**

119 ~~The~~ Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium  
120 carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum  
121 chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric,  
122 sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium  
123 ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ,

124 USA). Distilled water was purchased ~~by from a~~ local market (PT Aqua Surabaya, Surabaya,  
125 Indonesia).

### 126 **Wet noodles preparation**

127 Wet ~~n~~Noodles were prepared based on the modified formula of Panjaitan et al. <sup>[11]</sup>, as  
128 shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed  
129 with butterfly pea flower extract at various concentrations. ~~The S~~salt, water, ~~and~~ fresh whole egg  
130 ~~was were~~ then added and kneaded to ~~form a make~~ dough ~~by~~ using a mixer ~~machine~~ (Oxone Master  
131 Series 600 Standing Mixer OX 851, China). The dough was sheeted and cut ~~via using~~ rollers  
132 ~~equipped using with~~ cutting blades (Oxone OX355AT, China). ~~Raw w~~Wet noodle ~~strains s~~ were  
133 sprinkled with tapioca flour before heated in boiled water (100 °C) with a ratio of raw  
134 ~~noodles:noodles:~~ /water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil  
135 before ~~being~~ subjected to ~~measure the~~ quality and sensory properties ~~measurements, but whereas~~  
136 ~~uncooked the samples noodles without cooking and without~~ oil coating were used to analyze ~~the~~  
137 bioactive compounds and antioxidant activity.

### 138 **Extraction of bioactive compounds of wet noodles**

139 Wet noodles were extracted based on the method of Widyawati et al. <sup>[15]</sup>. Raw noodles  
140 were dried in ~~a~~ cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at  
141 60 °C for 2 h. The dried noodles were ~~grinded ground~~ using a chopper (Dry Mill Chopper Philips  
142 set HR 2116, PT Philips, Netherlands). ~~The About~~ 20 g of samples ~~were was~~ mixed with 50 mL  
143 of solvent mixture (1:1 v/v of methanol-/water), ~~and~~ stirred at 90 rpm in shaking water bath at 35  
144 °C for 1 h, and centrifuged at 5000 rpm for 5 min to obtain ~~the~~ supernatant. The ~~obtained~~ residue  
145 ~~obtained~~ was re-extracted in ~~the an~~ extraction time for ~~3 three~~ intervals. ~~The s~~Supernatant was  
146 evaporated using ~~a~~ rotary evaporator (Buchi-rotary evaporator R-210, Germany) at ~~condition of~~

147 70 rpm, 70 °C, and 200 mbar to ~~result-generate a~~ concentrated wet noodle ~~extracts~~. ~~Then, The~~  
148 ~~obtained~~ extract was used for further analysis.

149

### 150 **Moisture content analysis**

151 ~~The w~~Water content of cooked wet noodles was analyzed ~~based on thermogravimetry using~~  
152 ~~the thermogravimetric~~ method <sup>[32]</sup>. ~~About 1 g of the samples were-was~~ weighed in a weighing  
153 bottle and heated ~~by-in a~~ drying oven at 105-110 °C for 1 h. ~~The processes were followed by~~  
154 ~~weighing nthe samples were-and measuringweighed-and-measured~~ moisture content after ~~weight~~  
155 ~~obtaining a constant of sample weights-was-constant~~. The ~~m~~Moisture content ~~wasis~~ calculated  
156 based on the ~~difference of difference in sample weight beforeinitial~~ and ~~obtained after a~~ constant  
157 ~~sample weight is-reached~~ divided by the initial sample weight, expressed as a percentage of wet  
158 base.

### 159 **Water activity analysis**

160 ~~The w~~Water activity of cooked wet noodles was analyzed using A<sub>w</sub>-meter (Water Activity  
161 Hygropalm HP23 Aw a set 40 Rotronic, Swiss). ~~Ten grams of 40-g the samples were-were~~  
162 weighed, ~~d-and-entered-put into in-an~~ A<sub>w</sub> meter chamber, ~~and~~ analyzed ~~and data-recorded to obtain~~  
163 ~~the sample's water activity~~ <sup>[33]</sup>.

### 164 **Tensile strength analysis**

165 Tensile strength is ~~an~~ essential parameter that measures ~~the~~ extensibility of cooked wet  
166 noodles <sup>[39]</sup>. ~~About 20 cm of the samples were-was~~ measured ~~for its~~ tensile strength using a texture  
167 analyzer ~~that be~~ equipped ~~by-with a~~ Texture Exponent Lite Program and a ~~used~~ noodle tensile rig  
168 probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to ~~be~~ pre-set speed,



169 test speed, ~~and~~ post-test speed ~~at~~ 1 mm/s, 3 mm, ~~and~~ 10 mm/s, respectively. Distance, time, and  
170 trigger force ~~were set to were used~~ 100 mm, 5 sec, and 5 g, respectively.

### 171 **Color analysis**

172 ~~10-Ten grams of~~ cooked wet noodles were weighed in ~~a~~ chamber, and ~~the color was~~  
173 analyzed ~~color~~ using ~~a~~ color reader (Konica Minolta CR 20, Japan) based on the method of  
174 Harijati et al.<sup>[35]</sup>. ~~The p~~Parameters ~~measuredment was-were~~ lightness ( $L^*$ ), redness ( $a^*$ ),  
175 yellowness ( $b^*$ ), Hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ~~is~~ ranged 0-100 ~~that~~ expresses ~~d~~ brightness,  
176  $a^*$  value shows red color ~~which haswith~~ an interval between -80 - +100.  $b^*$  value ~~is~~ ~~represents a~~  
177 yellow color ~~that haswith~~ an interval of -70 - +70<sup>[36]</sup>. C ~~declares~~ ~~indicates the~~ color intensity and  
178  $^{\circ}h$  states ~~the~~ color of samples<sup>[37]</sup>.

### 179 **Swelling index analysis**

180 ~~The Swelling-swelling~~ index was determined ~~on-using the-a~~ modified method ~~of-by~~  
181 Islamiya et al.<sup>[38]</sup>. ~~Approximately 5 g of the~~ raw wet noodles were weighed in ~~a~~ chamber and  
182 cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was ~~analyzed to~~  
183 ~~measure~~ ~~measured to observe the~~ capability of raw wet noodles to absorb water that ~~increased the~~  
184 weight of raw wet noodles ~~increased~~<sup>[39]</sup>. The swelling index was measured from ~~the~~ difference in  
185 noodle weights ~~s~~ before and after boiling.

### 186 **Cooking loss analysis**

187 ~~The c~~Cooking loss of ~~the~~ raw wet noodles was analyzed ~~on-using the-a~~ modified method  
188 ~~of-by~~ Aditia et al.<sup>[40]</sup>. The cooking loss expresses ~~the~~ weight loss of wet noodles ~~for-during~~  
189 cooking, ~~that is signed~~ ~~indicated~~ by the cooking water ~~that turn to~~ cloudy and thick<sup>[41]</sup>. ~~About 5 g~~  
190 ~~of the~~ raw wet noodles ~~were-was~~ weighed in ~~a~~ chamber and cooked in 150 mL boiled water (100



191 °C) for 5 min., ~~Then, the~~ samples ~~were was~~ drained and dried ~~by in a~~ drying oven at 105 °C until  
192 the weight of the samples was constant.

### 193 **Total phenolic content analysis**

194 ~~The t~~Total phenolic content of ~~the~~ wet noodles was determined using Folin-Ciocalteu's  
195 phenol reagent based on the modified method ~~of by~~ Eyele et al.<sup>[42]</sup>. ~~About~~ 50 µL of ~~the~~ extract  
196 was added ~~with~~ 1 mL of 10 % Folin-Ciocalteu's phenol reagent in ~~a~~ 10 mL volumetric flask,  
197 ~~shaken~~~~homogenized~~, and incubated for 5 min. Then, 2 mL of 7.5 % Na<sub>2</sub>CO<sub>3</sub> was added, and the  
198 volume was adjusted to 10 mL with ~~distillated~~~~distilled~~ water. ~~Solution~~~~The solution's absorbance~~  
199 was measured ~~spectrophotometrically~~ ~~absorbance~~ at λ 760 nm (Spectrophotometer UV-Vis 1800,  
200 Shimadzu, Japan). The standard reference ~~was~~ used ~~was~~ gallic acid, and the result was expressed  
201 as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

### 203 **Total flavonoid content analysis**

204 Total flavonoid content was analyzed ~~on using~~ the modified method ~~using by~~ Li et al.<sup>[2013]</sup>.  
205 ~~The procedure began with mixing 0.3 mL of 5 % NaNO<sub>2</sub> and 250 µL of noodle extract in a 10 mL~~  
206 ~~volumetric flask and was added with 0.3 mL of 5% NaNO<sub>2</sub> and incubating the mixture ed for 5~~  
207 ~~min in a 10 mL volumetric flask. After 5 min of incubation~~~~Afterward~~, 0.3 mL of 10 % AlCl<sub>3</sub> was  
208 added ~~into the volumetric flask~~. After 5 min, 2 mL of 1 M NaOH was added, and the volume was  
209 adjusted to 10 mL with ~~distillated~~~~distilled~~ water. ~~The s~~Samples ~~were was~~ ~~mixed and~~ homogenized  
210 ~~before prior to was~~ ~~analy~~~~sized~~ using ~~a~~ spectrophotometer (Spectrophotometer UV-Vis 1800,  
211 Shimadzu, Japan) at λ. 510 nm. The result was determined using ~~a~~ (+)-catechin standard reference  
212 and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

### 213 **Total anthocyanin content analysis**

214 Total anthocyanin content was determined ~~on using~~ the method of Giustl and Wrolstad [44].  
215 ~~About~~ 250 µL ~~of the~~ samples ~~were was~~ added ~~with~~ buffer solutions at pH 1 and pH 4.5 in ~~different~~  
216 10 mL test tubes. ~~And~~ ~~T~~hen, each ~~of samples~~ ~~sample~~ was mixed and incubated for 15 min and  
217 measured at  $\lambda$  543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). ~~The~~  
218 ~~a~~Absorbance (A) of samples was calculated with formula:  $A = (A_{\lambda 543} - A_{\lambda 700})_{pH 1.0} -$   
219  $(A_{\lambda 543} - A_{\lambda 700})_{pH 4.5}$ . The total anthocyanin content (mg/mL) was calculated ~~by~~ ~~with~~  
220 formula:  $\frac{A \times MW \times DF \times 1000}{\epsilon \times l}$ , ~~w~~Where A was ~~the~~ absorbance, MW was ~~the~~ molecular weight of  
221 delphinidin-3-glucoside (449.2 g/mol), DF was ~~the~~ factor of sample dilution, and  $\epsilon$  was ~~the~~  
222 absorptivity molar of delphinidin-3-glucoside (29000 L cm<sup>-1</sup> mol<sup>-1</sup>).

223  
224

### 225 **2,2-Diphenyl-1-picrylhydrazyl DPPH free radical scavenging activity**

226 DPPH ~~analysis scavenging activity~~ was measured based on ~~the~~ methods of Shirazi et al.  
227 [45] and Widyawati et al. [46]. Briefly, 10 µL ~~of the~~ extract was added to a 10 mL test tube containing  
228 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark  
229 room. ~~The s~~Solution was centrifuged at 5000 rpm for 5 min, and ~~the~~ absorbance of samples was  
230 measured at  $\lambda$  517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). ~~The a~~Antioxidant  
231 activity of ~~the~~ samples was stated as ~~an~~ inhibition capacity with gallic acid as ~~the~~ standard reference  
232 and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

### 233 **Ferric reducing antioxidant power**

234 FRAP analysis ~~was was performed using used~~ the modified method of Al-Temimi and  
235 Choundhary [47]. ~~Approximately~~ 50 µL of ~~the~~ extract in a test tube was added ~~with~~ 2.5 mL of  
236 phosphate buffer solution at ~~p~~PH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and

237 incubated for 20 min at 50 °C. After incubation ~~20 min~~, the solution was added with 2.5 ml of 10  
238 % mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was  
239 taken and added with 2.5 mL of bi-distillated water and 2.5 mL of 0.1 % ferric chloride and  
240 incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda = 700$  nm  
241 (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). ~~Antioxidant capacity was used~~ Ggallic acid  
242 was used as the standard reference, and the results were expressed as in mg GAE (Gallic Acid  
243 Equivalent) per kg of dried noodles.

#### 244 **Sensory evaluation**

245 ~~Sensory~~ The sensory properties of cooked wet noodles were analyzed ~~on the modified~~  
246 ~~method using~~ based on Nugroho et al.<sup>[48]</sup> with modifications. ~~based on~~ The assessment used  
247 hedonic scale scoring, ~~including with the parameters including~~ color, aroma, taste, and texture  
248 attributes with 15 level, score 1 was stated as very dislike, and 15 was very like. ~~This sensory~~  
249 analysis ~~used was performed by~~ 100 untrained panelists between 17 and 25 years old who had  
250 previously gained knowledge of the measurement procedure ~~with ages between 17 until 25 year~~  
251 ~~old~~. The best treatment was determined by the index effectiveness test.

#### 252 **Design of experiment and statistical analysis**

253 ~~The Design~~ design of experiment used was a randomized block design (RBD) with two  
254 factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan)  
255 including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-  
256 butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment  
257 was ~~done performed~~ in three replications. ~~The homogenous data of~~ triplicate data analysis  
258 was were expressed as the mean  $\pm$  SD. The one-way analysis of variance (ANOVA) was done, and  
259 Duncan's New multiple range test (DMRT) was used to determine ~~for the~~ differences between

260 means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL,  
261 USA).

## 262 Results and discussions

### 263 Quality of Wet Noodles

264 ~~The q~~Quality ~~results~~ of ~~the~~ wet noodles, including moisture content, water activity, tensile  
265 strength, swelling index, cooking loss, and color, ~~was are~~ shown in Table 2 and Fig.1, 2, 3, and 4.  
266 Moisture content and water activity ( $A_w$ ~~W~~) of raw wet noodles were only significantly influenced  
267 ~~by~~ the various ratios of composite flour ( $p \leq 0.05$ ) (Fig. 1). However, the interaction of ~~the~~ two  
268 factors, the ~~difference in the ratios~~ of composite flour and the concentrations of butterfly pea  
269 extract, or the concentrations of butterfly pea extract itself, did not ~~have give any~~ significant effects  
270 on the water content and ~~AW~~ $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest  
271 water content (70 % wet base) compared to K0 (68 % wet base), K1 (68 % wet base), and K2 (69  
272 % wet base) because the samples had the highest ratio of  $\kappa$ -carrageenan. ~~The An increasing~~  
273 ~~increase~~ of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet  
274 noodle samples, ~~which also that~~ increased the water content of ~~the~~ wet noodles. Water content  
275 ~~measures resembles~~ the amount of free and weakly bound water in the ~~samples'~~ pores,  
276 intermolecular, and intercellular space ~~of samples~~ [15,28,49]. Protein networking between gliadin and  
277 glutelin forms a three-dimensional networking structure of gluten involving water molecules [49,50].  
278 The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of  
279 gluten network to ~~stability stabilize the~~ gluten network, ~~increasing that increases~~ water binding  
280 capacity and ~~retardings~~ the migration of water molecules [50,52].  $\kappa$ -carrageenan can bind water  
281 molecules around 25-40 times [51]. The  $\kappa$ -carrageenan can cause ~~the a~~ structure change of gluten  
282 protein ~~throug~~h electrostatic interactions and hydrogen bonding [52,55]. ~~The i~~Interaction among

283 the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -  
284 carrageenan also changed the conformation of the three-dimensional network structure formation  
285 involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular disulfide bonds that  
286 ~~is be able to~~ establish water mobility in the dough of ~~this the~~ wet noodles. The ~~effect of this~~  
287 interaction of all components ~~of in the~~ composite flour significantly influenced ~~of~~ the amount of  
288 free water ( $p \leq 0.05$ ) (Fig. 1). The addition of  $\kappa$ -carrageenan between 1-3% in the wet noodle  
289 formulation reduced the ~~AW- $A_w$  by~~ about 0.005-0.006. The capability of  $\kappa$ -carrageenan ~~absorbed~~  
290 to absorb water molecules reduces the water mobility in the wet noodles due to the ~~involving~~  
291 involvement of hydroxyl, carbonyl, and ester ~~sulphate-sulfate~~ groups of them to form complex  
292 structures [535-57]. The complexity of the reaction among components in the wet noodles to form a  
293 three-dimensional networking influenced the amount of free water molecules that determined  
294 water activity values. The strength of the bonding among the components ~~arranged between of~~ wet  
295 noodles and water molecules also ~~specified contributed to~~ the value of the water activity.

296 Tensile strength, swelling index, and cooking loss of cooked wet noodles ~~was were~~  
297 significantly influenced by each factors of the ratios of composite flour or the concentrations of  
298 butterfly pea flower extract ( $p \leq 0.05$ ) (Fig. 1 and 2). ~~However, , but~~ the interaction ~~of the various~~  
299 ~~ratio of composite flour and the concentration of butterfly pea extract between the two factors~~ was  
300 not ~~significant seen to~~ influenced the tensile strength, swelling index, and cooking loss of wet  
301 noodles ( $p \leq 0.05$ ) (Table 2). ~~The An~~ increasing ~~of in~~ the ratio of  $\kappa$ -carrageenan in the composite  
302 flour increased the tensile strength and swelling index, and decreased the cooking loss of wet  
303 noodles. ~~On the other hand, , but~~ the increasing ~~of the concentration of~~ butterfly pea extract  
304 concentration decreased the tensile strength and increased the swelling index and cooking loss of  
305 wet noodles. ~~The effect of the Different~~ ratios of the composite flour ~~to affected~~ the tensile strength,

306 ~~which~~ ranged between 0.197 ~~to and~~ 0.171 g. ~~At the same time, While the addition of incorporating~~  
307 butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) ~~to significantly~~  
308 ~~decrease from lower~~ around 0.003 ~~until to~~ 0.008 than control (K1). The highest ~~and lowest~~  
309 swelling index values ~~was were~~ owned by K3 ~~and K0~~ samples, ~~respectively and the lowest swelling~~  
310 ~~index values were belonging of the K0 sample~~. The swelling index values of wet noodles ranged  
311 ~~around from~~ 128 to 159 ~~-%~~. The effect of ~~the~~ composite flour proportion of wet noodles showed  
312 that ~~the~~ K0 sample had the highest cooking loss, and ~~the~~ K3 sample possessed the lowest cooking  
313 loss. ~~In contrast, While~~ the effect of the concentrations of butterfly pea extract resulted ~~in~~ the  
314 lowest cooking loss values of ~~the~~ T0 sample and the highest cooking loss values of ~~the~~ T30 sample.  
315 The cooking loss values of wet noodles ranged ~~around from~~ 18 to 19 ~~-%~~.

316 Tensile strength, cooking loss, and swelling index of wet noodles ~~was were~~ clearly  
317 ~~significantly~~ influenced by ~~participation the interaction~~ of components in dough formation, ~~the~~  
318 ~~interaction among namely~~ glutelin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic  
319 compounds, ~~which~~ resulted ~~in~~ a three-dimensional network  
320 ~~k~~  
321 structure ~~that~~ determined ~~the~~ capability of ~~resistance of~~ the noodle strands ~~being resistance~~ to break  
322 and gel formation. ~~—~~  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide  
323 composed ~~of a~~ hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group  
324 linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages-<sup>[548,59]</sup> that can bind water molecule to form a gel.  
325 Glucomannan is a soluble fiber with ~~the  $\beta$ -1,4 linkage~~ main chain  ~~$\beta$ -1,4 linkage~~ of D-glucose and  
326 D-mannose that can absorb water molecules around 200 times <sup>[5560]</sup> to form a strong gel that  
327 increases ~~the~~ viscosity and swelling index of ~~the~~ dough <sup>[5664]</sup>. Park and Baik <sup>[5762]</sup> ~~stated that the~~  
328 ~~gluten network formation affects the tensile strength of noodle~~ ~~claimed that tensile strength of~~

329 ~~noodles is affected by gluten network formation.~~ Huang et al. <sup>[535]</sup> also reported that  $\kappa$ -carrageenan  
330 can increase the firmness and viscosity of samples because ~~of the this hydrocolloid's strong water-~~  
331 ~~binding capacity of this hydrocolloid is very strong.~~ Cui et al. <sup>[504]</sup> claimed that konjac  
332 glucomannan ~~does~~ not only stabilizes the structure of gluten network but also reacts with free water  
333 molecules to form a more stable ~~of a~~ three-dimensional networking structure, thus holding  
334 maintaining the dough's rheological and tensile properties ~~of dough.~~

335 The increasing ~~of ed~~ swelling index of dough is caused by the capability of glucomannan  
336 to reduce the pore size and increase the pore numbers with uniform size <sup>[5863]</sup>. The synergistic  
337 interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and  
338 stable gel because of the association and lining up of the mannan molecules into the junction zones  
339 of helices <sup>[5964]</sup>. The cross-linking and polymerization involving functional groups of gluten  
340 protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces s with each other. The stronger  
341 attraction between molecules composed of cross-linking reduces the particles or molecules' loss  
342 during cooking <sup>[59,6064-66]</sup>. ~~The s~~Stability of the network dimensional structure of the protein was  
343 influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol  
344 compounds in ~~the dough of~~ wet noodle doughs that determined tensile strength, swelling index,  
345 and cooking loss of wet noodles. Schefer et al. <sup>[27]</sup> and Widyawati et al. <sup>[15]</sup> explained that phenolic  
346 compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin)  
347 and carbohydrate (amylose) to form a complex structure through many interactions, including  
348 hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking.  
349 The phenolic compounds of butterfly pea extract ~~were~~ interacted with  $\kappa$ -carrageenan,  
350 glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic  
351 compounds can disrupt a the three-dimensional networking of interaction among gluten protein,



352  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and  
353 noncovalent bonds, and disruption of disulfide bridges to form thiols radicals [60,65,66]. These  
354 compounds can form complexes with protein and hydrocolloids, leading to structural and  
355 functional changes and influencing gel formation through aggregation formation and disulfide  
356 disulfide bridges breakdown [26,27,617].

357 The color of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction  
358 between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $h$  increased  
359 with increasing the ratio of composite flour ratio and the concentration of butterfly pea extract.  
360 Most of the color parameters values were lower than the control samples (K0T0, K1T0, K2T0,  
361 K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increasing of  
362 amount of butterfly pea extract changed all color parameters. The ranges of  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $h$   
363 ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness,  
364 redness, and yellowness of wet noodles grew intensified with going up a higher  $\kappa$ -carrageenan  
365 proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of  
366 wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15, and then  
367 increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments  
368 ( $p \leq 0.05$ ). The presence of  $\kappa$ -carrageenan in composite flour also supported the water-holding  
369 capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan  
370 to produce a strong, stable network that involved sulfhydryl groups. Masakuni Take and Konishi  
371 [628] reported that  $\kappa$ -carrageenan is capable to associate making polymer structure that  
372 involves intra- and intermolecular interaction, such as ionic bonding and electrostatic forces. The  
373 mechanism of making a three-dimensional network structure that implicated all components of  
374 composite flour was very exceptionally complicated because they due to the involved polar and



375 non-polar functional groups and many kinds of interaction ~~of-between~~ them. These ~~were~~  
376 influenced ~~the~~ water content and water activity of ~~the~~ wet noodles, ~~whichs-that-were~~ impacted ~~the~~  
377 wet noodle color. ~~Another possible~~~~The other~~ cause ~~that affects wet noodles' color profile of wet~~  
378 ~~noodles-was~~ anthocyanin pigment from ~~the~~ butterfly pea extract. Gamage et al.<sup>[639]</sup> reported that  
379 ~~the~~ anthocyanin pigment of butterfly pea is delphinidin-3-glucoside ~~and having-has a~~ blue color.  
380 Increasing ~~butterfly pea of~~ extract concentration ~~declined-lowered the~~ lightness, redness,  
381 yellowness, ~~and-and~~ chroma ~~and also-as-well-as~~ changed ~~the~~ hue color from yellow to ~~be-green-~~  
382 ~~until~~ blue color.

383 The effect of composite flour and butterfly pea extract on color was observed in chroma  
384 and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness,  
385 but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[6470]</sup> ~~and Padmawati et al.~~<sup>[74]</sup>  
386 also found ~~ed~~ similarities ~~of-in~~ their research. Anthocyanin pigment of butterfly pea extract can  
387 ~~be-interacted~~ with ~~the~~ color of stinky lily and  $\kappa$ -carrageenan, impacting ~~theed~~ color change of wet  
388 noodles. Thus, the sample T0 ~~is-was~~ yellow-~~color~~, T15 ~~is-was~~ green, ~~color~~ and T30 ~~is-was~~ blue  
389 ~~color~~. Color intensity showed as chroma values of yellow values increased along with ~~the~~ higher  
390 proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract, ~~but-However,~~ the  
391 higher concentration of butterfly pea extract ~~declined-lessened the~~ green and blue colors of wet  
392 noodles ~~at-made using thethe~~ same proportion of composite flour. Wet noodle color ~~is~~ also  
393 estimated to be influenced by the phenolic compound content, which underwent polymerization  
394 or degradation during ~~the~~ heating ~~processses~~. Widyawati et al.<sup>[28]</sup> reported that ~~the~~ bioactive  
395 compounds in pluchea extract ~~can-could~~ change ~~the~~ wet noodle color because of ~~the~~ discoloration  
396 of pigment during cooking. ~~-~~K2T30 was wet noodles ~~having-exhibiting the~~ strongest blue color

397 due to different interactions ~~of between~~ anthocyanin and hydrocolloid compounds, especially  $\kappa$ -  
398 carrageenan, that ~~were capable to reduce~~ could reduce the intensity of blue color or chroma values.

399

400 **The ~~content of~~ phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) contents**  
401 **of wet noodles**

402 The results of TPC, TFC, and TAC ~~were are~~ shown in Fig. 5. -The TPC and TFC of wet  
403 noodles were significantly influenced by the interaction between two parameters: ~~of~~ the ratio of  
404 composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion  
405 of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had  
406 the highest TPC and TFC ~~as of about~~ ~ 207 mg GAE/kg dried noodles and ~57 mg CE/kg dried  
407 noodles, respectively. ~~While~~ The TAC of wet noodles was only influenced by the concentration  
408 of butterfly pea extract, and the increase in extract addition ~~leading led~~ to an increase in TAC. The  
409 extract ~~substitution addition at in~~ T30 ~~was obtained~~ possessed a TAC ~~about of about~~ 3.92 $\pm$ 0.18 mg  
410 delfidine-3-glucoside/kg dried noodles of TAC. ~~Based on~~ In addition, based on Pearson correlation  
411 assessment, there was a strong, positive correlation ~~Pearson correlation, between the~~ TPC of wet  
412 noodles ~~was strong and positive correlated with and the~~ TFC at T0 ~~treatment~~ ( $r = 0.955$ ), T15  
413 ~~treatment~~ ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, , while a weak, positive correlation  
414 was observed between the TPC of samples ~~was weak and positive correlated with and the~~ TAC at  
415 T0 ~~treatment~~ ( $r = 0.153$ ) and T30 treatments ( $r = 0.067$ ), except the ~~samples at~~ T15 treatment, which  
416 had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were  
417 correlated with their quality properties and antioxidant activity (AOA). The d Dominant  
418 anthocyanin pigment from butterfly pea extract is delphinidin <sup>[6572]</sup>, around 2.41 mg/g samples <sup>[6673]</sup>  
419 that has free more acyl groups and aglycone structure <sup>[6774]</sup> ~~and that~~ can be used as a natural

420 pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is  
421 ~~a~~ potential ~~as~~ antioxidant agent through ~~the~~ free-radical scavenging pathway, cyclooxygenase  
422 pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling [6875,76].  
423 Nevertheless, butterfly pea extract ~~is~~ also composed ~~s~~ of tannins, phenolics, flavonoids,  
424 phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol,  
425 stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol,  
426 quercetin, myricetin, 6''-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and  
427 coumaroyl glucose) [20,21], chlorogenic, gallic, p-coumaric, caffeic, ferulic, protocatechuic, p-  
428 hydroxy benzoic, vanillic, and syringic acids [6774], ternatin anthocyanins, fatty acids, tocopherols, mome  
429 inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), ~~and~~ hirsutenone [6977,78], that  
430 contribute to ~~have the~~ antioxidant activity [18,6978]. *Clitoria ternatea* shows ~~to exhibit potential as~~  
431 antioxidant activity based on ~~an the~~ antioxidant assays, such as 2,2- diphenyl-1-picrylhydrazyl  
432 radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical  
433 scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity  
434 (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-  
435 bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power  
436 assays [6978]. ~~The~~ TPC and TFC of wet noodles increased along with the higher proportion of  
437 glucomannan in ~~the~~ composite flour and the higher concentration of butterfly pea extract. Zhou et  
438 al. [7079] claimed that glucomannan ~~contained~~ in stinky lily has hydroxyl groups that can ~~be reacted~~  
439 with Folin Ciocalteu's phenol reagent. Devaraj et al. [7180] reported that 3,5-acetylalbulin is ~~a~~  
440 flavonoid compounds in glucomannan ~~that can be bound complexes form a complex~~ with  $\text{AlCl}_3$ .

#### 441 **Antioxidant activity of wet noodles**

442 The antioxidant activity (AOA) of wet noodles was determined using DPPH radical  
443 scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Fig. 5.  
444 The proportion of composite flour and the concentration of butterfly pea extracts significantly  
445 affected the DPPH results ( $p \leq 0.05$ ). The noodles had exhibited DPPH values ranging from 3 to 48  
446 mg GAE/kg dried noodles. The Several wet noodle samples, including the composite flour of K0  
447 and K1 and without of butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the  
448 samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest  
449 DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated  
450 with the DPPH (Table 7). The Correlated coefficient values (r) between TPC and AOA at T0,  
451 T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Whereas Meanwhile, the r  
452 values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, at T15 treatment  
453 were 0.739, and at T30 treatment were 0.753, respectively. However, the correlation coefficient  
454 values between TAC and AOA at T0, T15 and T30 treatments were 0.123, 0.127, and 0.194,  
455 respectively. The interaction among glucomannan, phenolic compounds, amylose, gliadin, and  
456 glutelin in the dough of wet noodles determined the number and position of free hydroxyl groups  
457 of them that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[46]</sup> said-stated that free radical  
458 inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl  
459 groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH  
460 significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and  
461 butterfly pea extract for significantly up to 18 and 2% (w/w) of stinky lily flour glucomannan and  
462  $\kappa$ -carrageenan and 15% (w/w) of extract. However, but the using-use of 17 and 3% (w/w) of  
463 stinky lily flour glucomannan and  $\kappa$ -carrageenan and 30% (w/w) of extract showed a significant  
464 decrease. This-The results showed that the use of stinky lily flour and k-carrageenan with a ratio

465 of 17:3 % (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or  
466 hydrogen donors in testing TPC, TFC, and DPPH.

467 FRAP of wet noodles was significantly influenced by the interaction of two parameters of  
468 the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.055\%$ ).  
469 FRAP was used to measure the capability of antioxidant compounds to reduce  $Fe^{3+}$  ions to be  $Fe^{2+}$   
470 ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to  
471 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts  
472 (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30 % of  
473 butterfly pea extracts 30% (K2T30) had the highest FRAP. The Pearson correlation values showed  
474 that TPC and TFC at T0 and T30 treatments had strong and positive correlation to FRAP  
475 activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation  
476 coefficient (r) values of TAC at T0 treatment was weak and with positive correlation to  
477 FRAP samples, but the r values at T15 and T30 treatments showed weak and negative  
478 correlations (Table 3). The obtained correlation between DPPH and FRAP activities was  
479 obtained that the DPPH method was highly correlated with the FRAP method at T0 and  
480 T30 treatments and lowly weakly correlated at T15 treatment (Table 3). Based on the DPPH and  
481 FRAP methods showed the that capability of wet noodles to scavenge free radical was higher than  
482 them to reduce ferric ion. It proved that the bioactive compounds of wet noodles were are more  
483 potential as free radical scavengers or hydrogen donors than as donor electron donors. Compounds  
484 that have capability to reducing power can act as primary and secondary antioxidants [7281,82]. Poli  
485 et al. [783] said stated that bioactive compounds acted as DPPH free radical scavenging activity are  
486 grouped as a primary antioxidant. Nevertheless, Suhendy et al. [7484] claimed that a secondary  
487 antioxidant is a natural antioxidant that has capability to reduce ferric ion (FRAP). Based on AOA

488 assay results, ~~the results showed that~~ phenolic compounds indicated a strong and positive  
489 correlation with flavonoid compounds, ~~as because of flavonoids they are~~ the major phenolic  
490 compounds ~~that are~~ potential as antioxidant ~~activities agents pass~~ through their ability to  
491 scavenge highly effective scavenger of various free radicals. The effectivity of flavonoid  
492 compounds ~~to in~~ inhibiting free radicals and chelating agents is influenced by the number and  
493 position of hydrogen groups and conjugated diene at A, B, and C rings <sup>[7585-87]</sup>. Previous studies  
494 have proven that TPC and TFC ~~exhibit~~ significantly contribute ~~or~~ to scavenge free radicals <sup>[7688-</sup>  
495 <sup>90]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al. <sup>[7689]</sup>  
496 stated that TPC and anthocyanins have a significant and positive correlation with AOA, but  
497 anthocyanins ~~were~~ insignificantly correlated with AOA. Different structure of anthocyanins in  
498 samples determines AOA. ~~Moreover, the polymerization or complexion of Polymer~~  
499 ~~anthocyanins or anthocyanin complexed~~ with other molecules ~~assign~~ also determines their  
500 capability ~~as of them to~~ electron or hydrogen donors. ~~Martin et al.~~ <sup>[7794]</sup> informed that ~~the~~  
501 anthocyanins are the major groups of phenolic pigments ~~that are an essential~~ where their  
502 antioxidant activity greatly depends on ~~a the~~ steric hindrance of their chemical structure, such as  
503 number and position of hydroxyl groups and the conjugated double bonds, as well as the presence  
504 of electron in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly  
505 and positively correlated with FRAP assay due to the role of phenolic compounds ~~involved as~~  
506 reducing power agents that contributed ~~them to~~ ~~donor~~ donating electrons. Paddayappa et al. <sup>[7282]</sup>  
507 reported that the phenolic compounds are capable ~~to of~~ embroidering redox activities with an  
508 action as hydrogen donor and reducing agents. The weakly relationship between TPC, ~~or~~ TFC, or  
509 DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the  
510 functional groups in the benzene ring in phenolic and flavonoid compounds and the functional

511 groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid  
512 compounds to donate electrons.

### 513 **Sensory Evaluation**

514 Sensory properties of wet noodles based on ~~the~~ hedonic ~~method test results~~, showed that  
515 composite flour and butterfly pea extract additions significantly influenced color, aroma, taste, and  
516 texture preferences ( $p \leq 0.05$ ) (Table 4).- The preference values of color, aroma, taste, and texture  
517 attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. ~~The~~  
518 ~~using~~ ~~Incorporating~~ ~~of~~ butterfly pea extracts decreased preference values of color, aroma, taste, and  
519 texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities  
520 of wet noodle's color that resulted ~~in~~ color degradation from yellow, green, ~~until to~~ blue color,  
521 ~~impacted~~ ~~impacting~~ ~~the~~ color preference of wet noodles. Nugroho et al.<sup>[48]</sup> also informed that ~~the~~  
522 addition of butterfly pea ~~extract~~ ~~extracts~~ ~~upgraded~~ ~~elevated~~ ~~the~~ preference of panelists ~~to for~~ dried  
523 noodles. ~~The a~~ Aroma of wet noodles was also affected by two parameters of treatments, ~~where~~ the  
524 results showed that the higher proportion of stinky lily caused ~~the~~ ~~the~~ ~~wet~~ ~~noodles~~ ~~to~~ ~~have~~ ~~a~~  
525 stronger, musty smell ~~of wet noodles~~. Utami et al. <sup>[7892]</sup> claimed that oxalic acid ~~of~~ ~~contained~~ ~~in~~  
526 stinky lily flour contributes to ~~the~~ odor of rice paper. Therefore, a high proportion of k-carrageenan  
527 ~~can~~ ~~could~~ reduce the proportion of stink lily flour, thereby increasing the panelists's preference  
528 for ~~wet noodle~~ aroma. Sumartini and Putri<sup>[7993]</sup> ~~informed~~ ~~noted~~ that panelists ~~is~~ ~~preferred~~ ~~more~~ ~~like~~  
529 noodles substituted ~~the~~ ~~with~~ ~~a~~ higher  $\kappa$ -carrageenan.- ~~Kurniadi et al.~~<sup>[94]</sup> ~~and~~ Widyawati et al.<sup>[15]</sup>  
530 ~~said~~ ~~also~~ ~~proved~~ that  $\kappa$ -carrageenan is ~~an~~ odorless material ~~which~~ ~~that~~ ~~doesn't~~ ~~does~~ ~~not~~ ~~result~~ ~~affect~~  
531 ~~the~~ aroma of wet noodles.- Neda et al. <sup>[6877]</sup> added that volatile compounds of butterfly pea extract  
532 can mask ~~the~~ musty smell of stinky lily flour, such as pentanal and mome inositol,; ~~In~~ ~~addition~~,  
533 Padmawati et al.<sup>[8074]</sup> ~~informed~~ ~~revealed~~ that ~~they~~ ~~butterfly~~ ~~pea~~ ~~extract~~ ~~can~~ ~~could~~ ~~gave~~ ~~give~~ ~~a~~



534 sweet and sharp aroma. The panelists' taste preference of panelist to wet noodles without butterfly  
535 pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[8195]</sup>, due to Maillard reaction  
536 of during stinky lily flour processing. Nevertheless, using of butterfly pea extract at a higher  
537 concentration of in wet noodles increased the bitter taste, which is contributed by related to tannin  
538 compounds in this flower, as has been found, this is supported by Hasby et al.<sup>[96]</sup> and Handayani  
539 and Kumalasari<sup>[8297]</sup>. The effect of composite flour proportion and butterfly pea extract addition  
540 also appeared to the texture preference of wet noodles. Panelists was likely preferred wet noodles  
541 that was did not break up easily, which was that the K3T0 sample, as the treatment resulted in  
542 were chewy and elastic wet noodles. This was supported by the results were also affected by the  
543 tensile strength of wet noodles because of the different concentrations of butterfly pea extract  
544 added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted  
545 in sticky, break easy to break, and less chewy wet noodles<sup>[26,27,82,85,97]</sup> due to the competition  
546 among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact  
547 with water molecules to form gel<sup>[8398]</sup>. Based on the index effectiveness test, the noodles including  
548 made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best  
549 treatment, with a total score of 1.0504.

## 550 Conclusions

551 Using of composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and  
552 butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive compounds,  
553 antioxidant activity, and sensory properties of wet noodles. Interaction among glutelin, gliadin,  
554 amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds determined affected a the three-  
555 dimensional network structure that impacted moisture content, water activity, tensile strength,  
556 color, cooking loss, and swelling index, bioactive content, antioxidant activity, and sensory



557 properties of wet noodles.—The higher concentration of hydrocolloid addition caused ~~increasing~~  
558 ~~increased of~~ water content and swelling index and ~~decreasing~~ ~~decreased of~~ water activity and  
559 cooking loss. In addition, incorporating ~~Addition of~~ butterfly pea ~~extract~~ extracts improved color,  
560 bioactive content, and antioxidant activity and ~~repaired~~ enhanced panelist preference ~~of for~~ wet  
561 noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract ~~were~~  
562 ~~able to increase~~ increased the functional value of resulting wet noodles.

563

564

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568

### 569 **Conflict of Interest**

570 The authors declare no conflict of interest

571

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916 Table 1. Formula of wet noodles

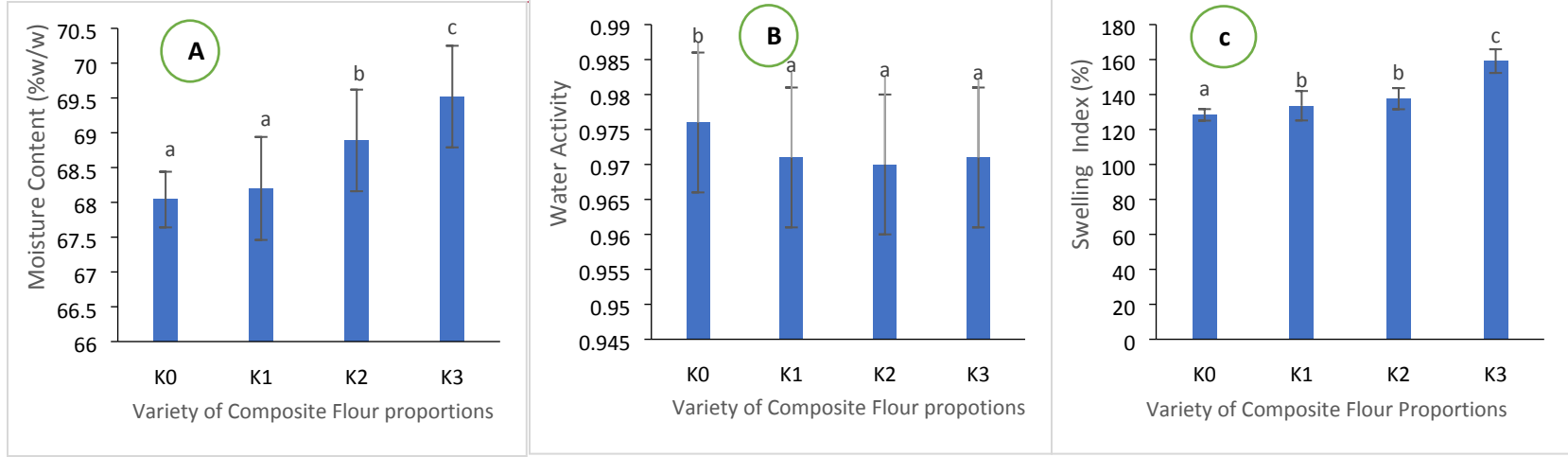
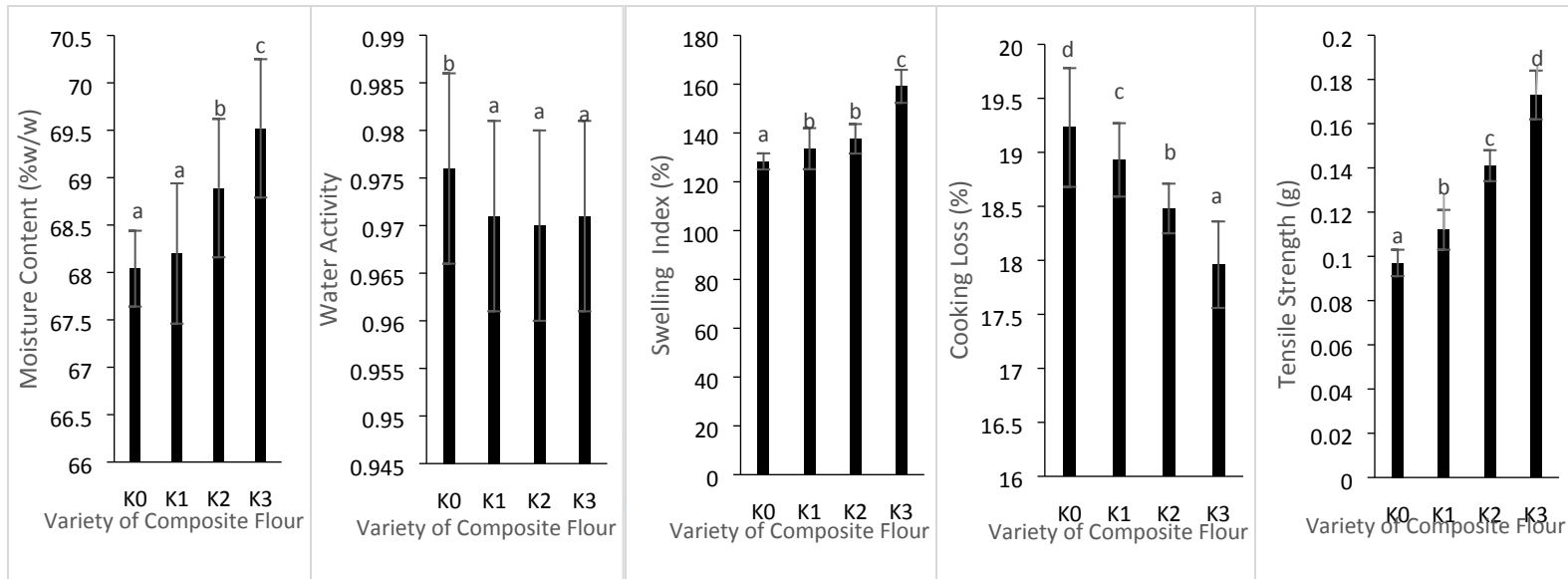
Treatment	Code	Ingredients					Composite flour (g)
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)		
1	K0T0	3	30	30	0	150	
2	K0T15	3	30	0	30	150	
3	K0T30	3	30	0	30	150	
4	K1T0	3	30	30	0	150	
5	K1T15	3	30	0	30	150	
6	K1T30	3	30	0	30	150	
7	K2T0	3	30	30	0	150	
8	K2T15	3	30	0	30	150	
9	K2T30	3	30	0	30	150	
10	K3T0	3	30	30	0	150	
11	K3T15	3	30	0	30	150	
12	K3T30	3	30	0	30	150	

917 Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (% w/w). K1 = wheat flour: stink  
 918 lily flour:  $\kappa$ -carrageenan = 80:19:1 (% w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan =  
 919 80:18:2 (% w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (% w/w). T0 =  
 920 concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract =  
 921 15%. T30 = concentration of the butterfly pea extract = 30%.

Table 2. Quality properties of wet noodles at the various ratio of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: **No significant effect** of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles **at  $p \leq 0.05$ .**



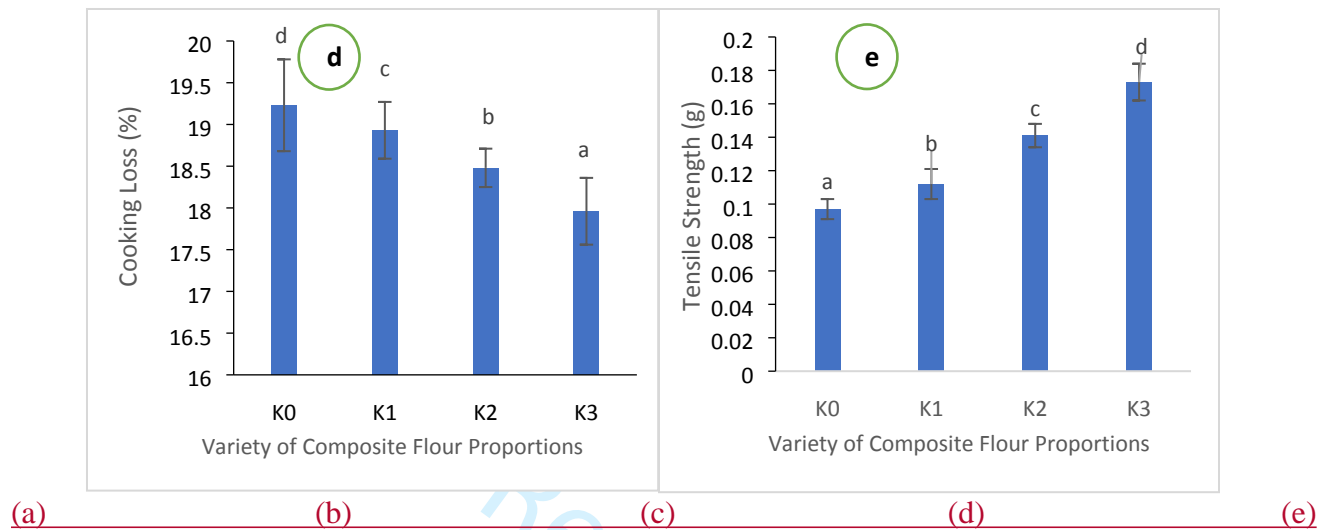
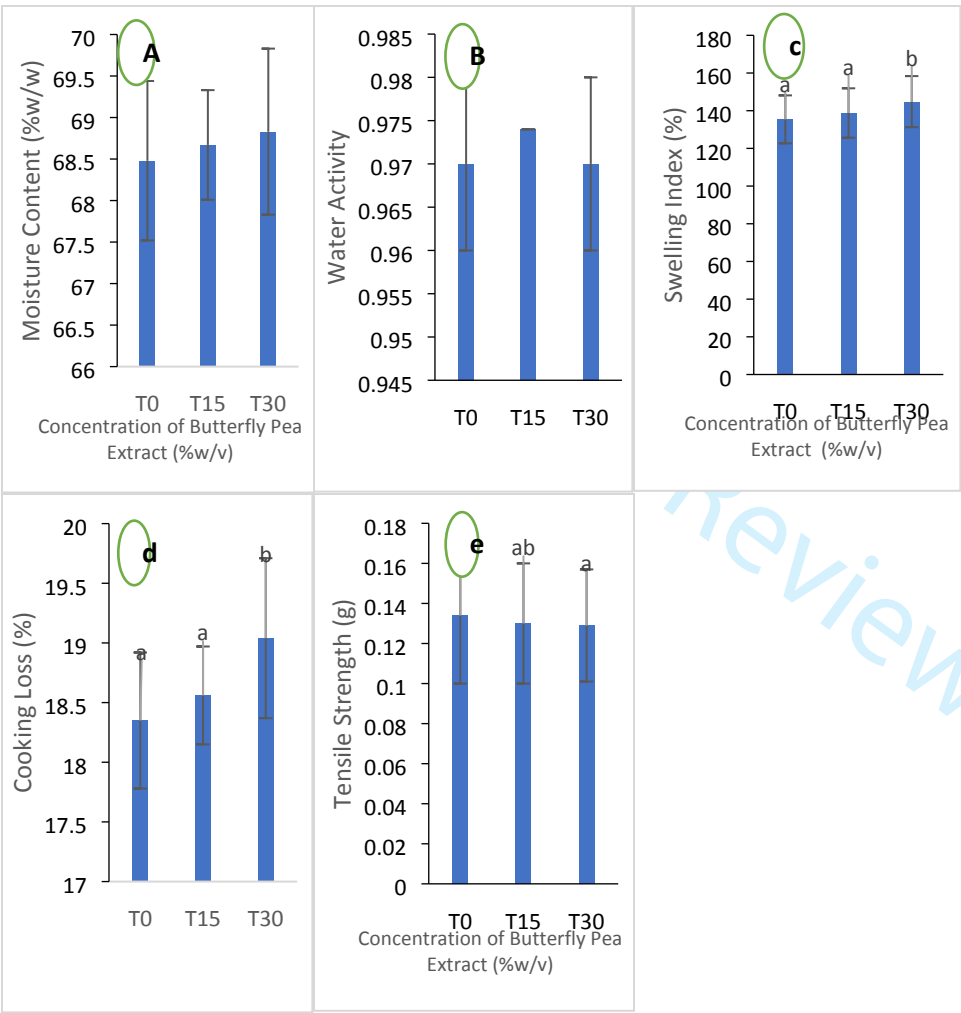


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.055\%$ .



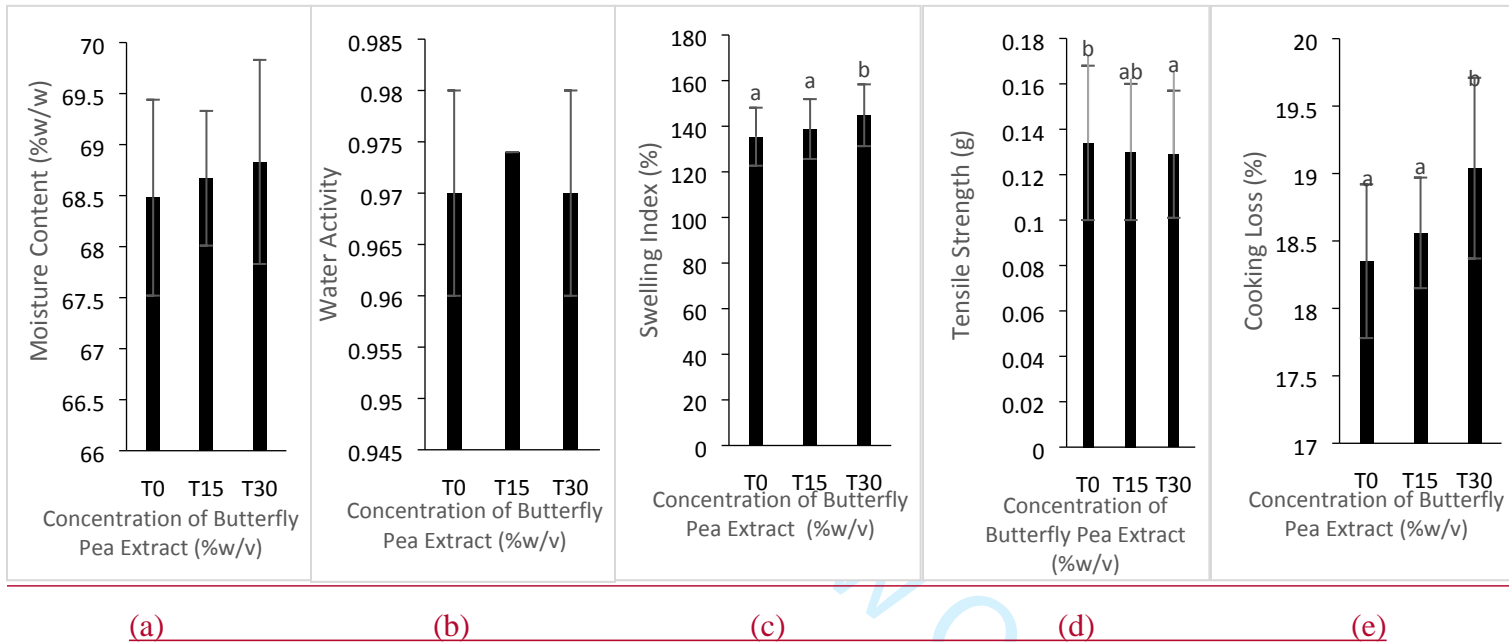
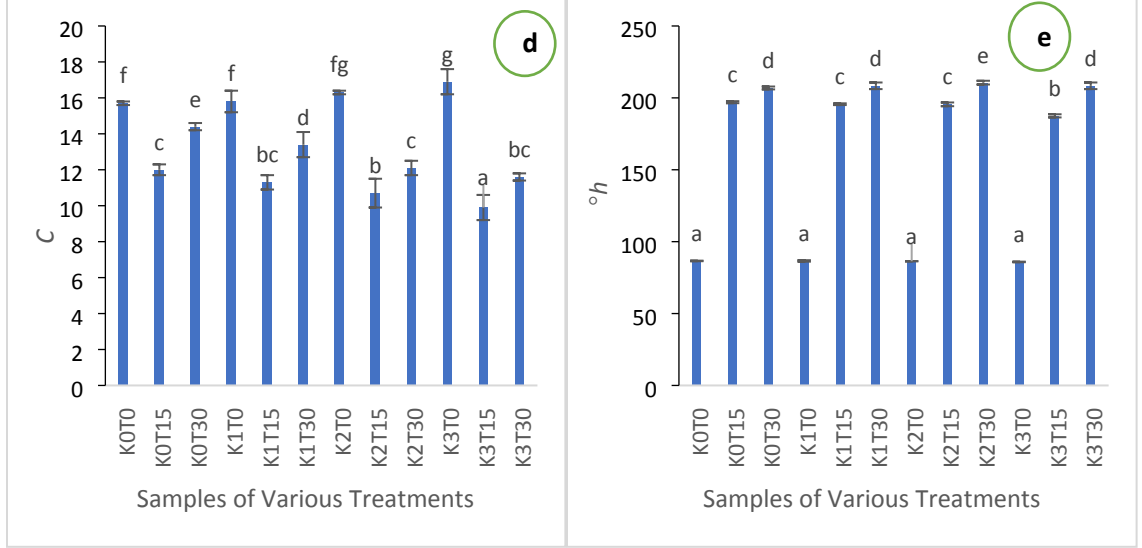
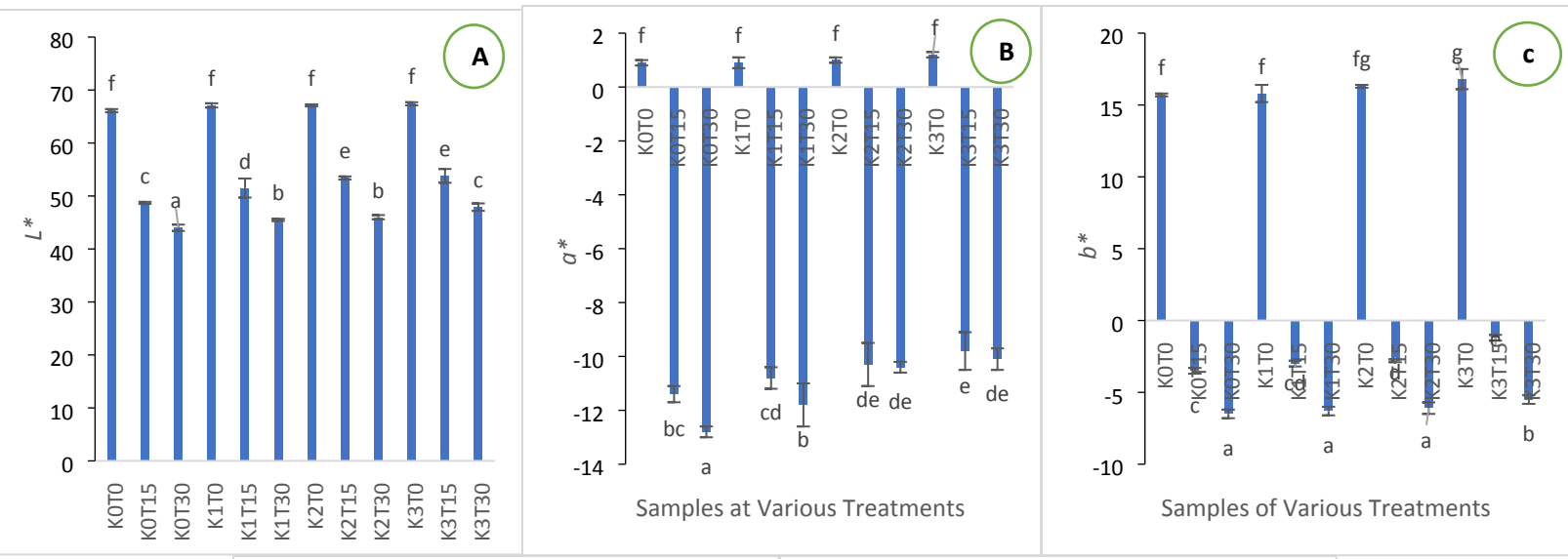


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.055\%$ .





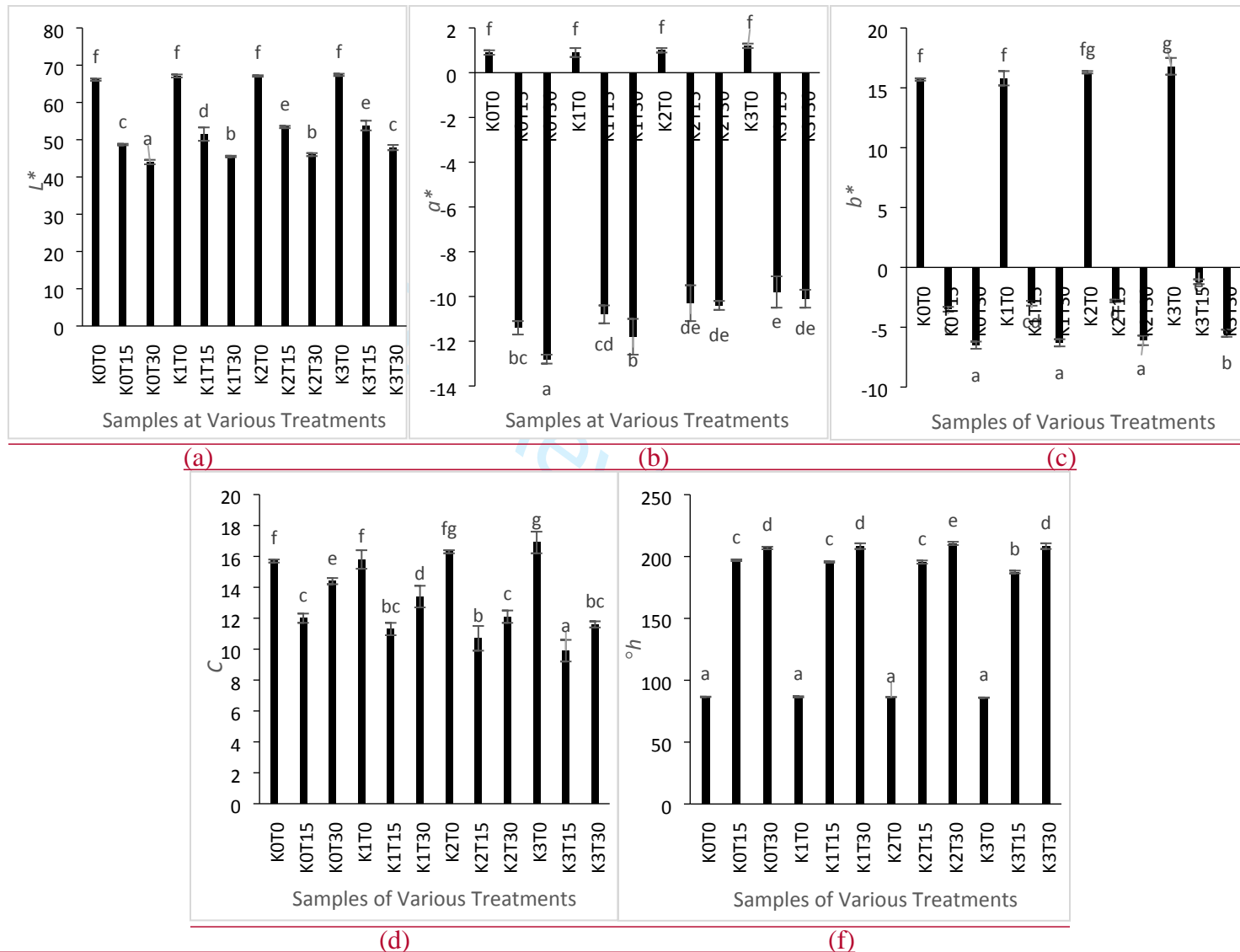


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/h°*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p < 0.055\%$ .

~~Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .~~

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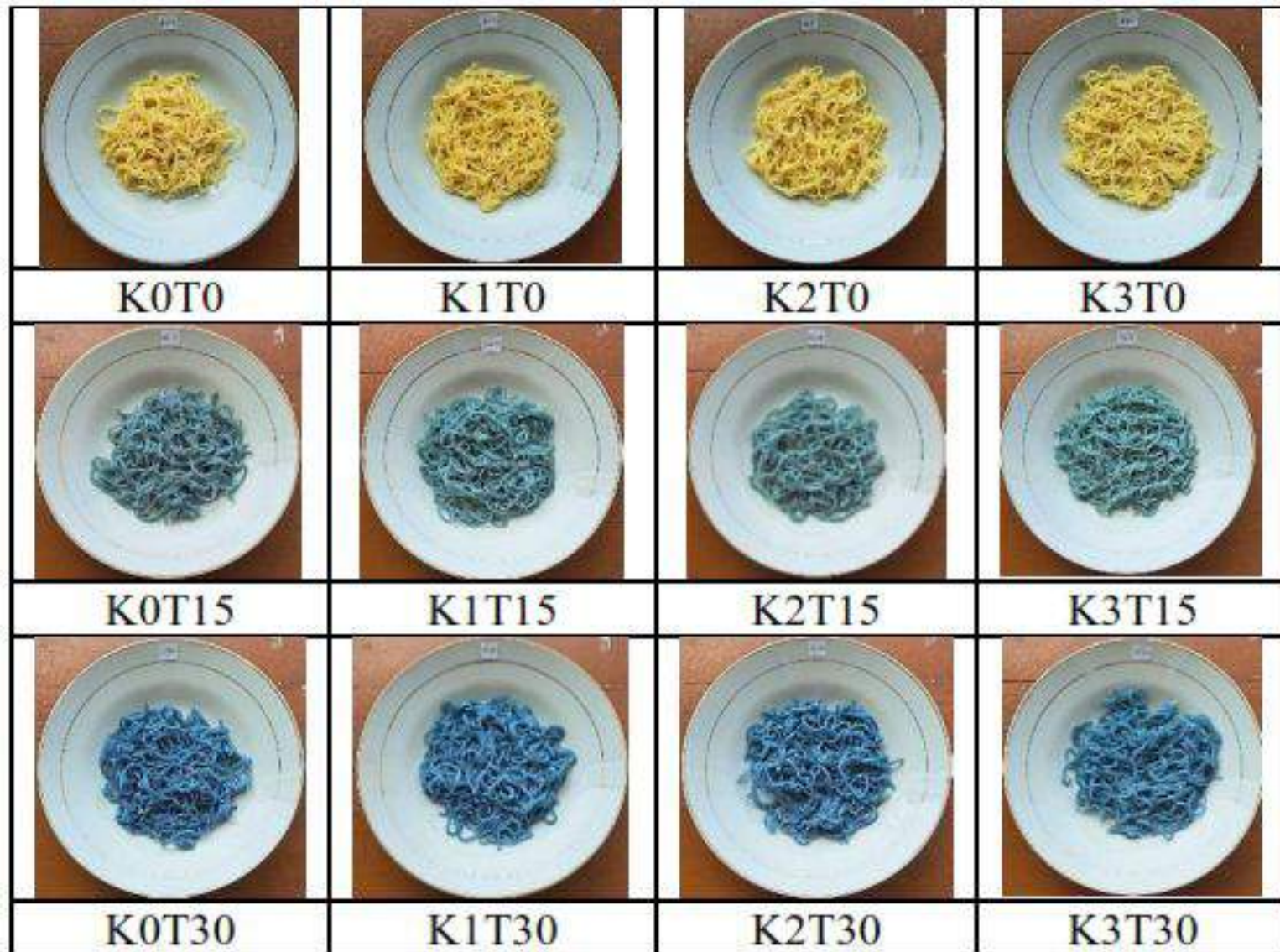
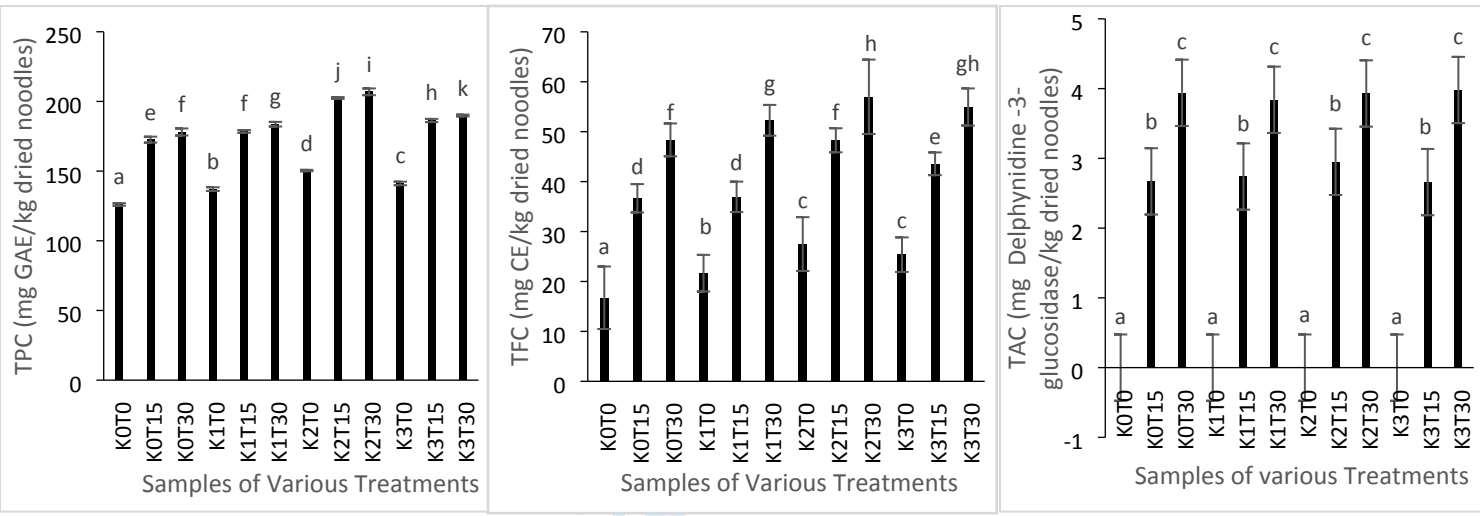


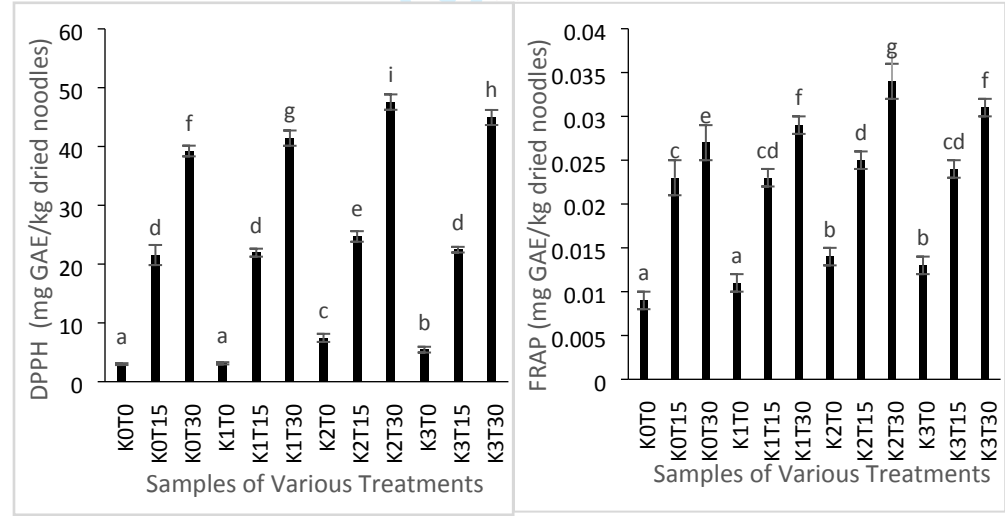
Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract



(a)

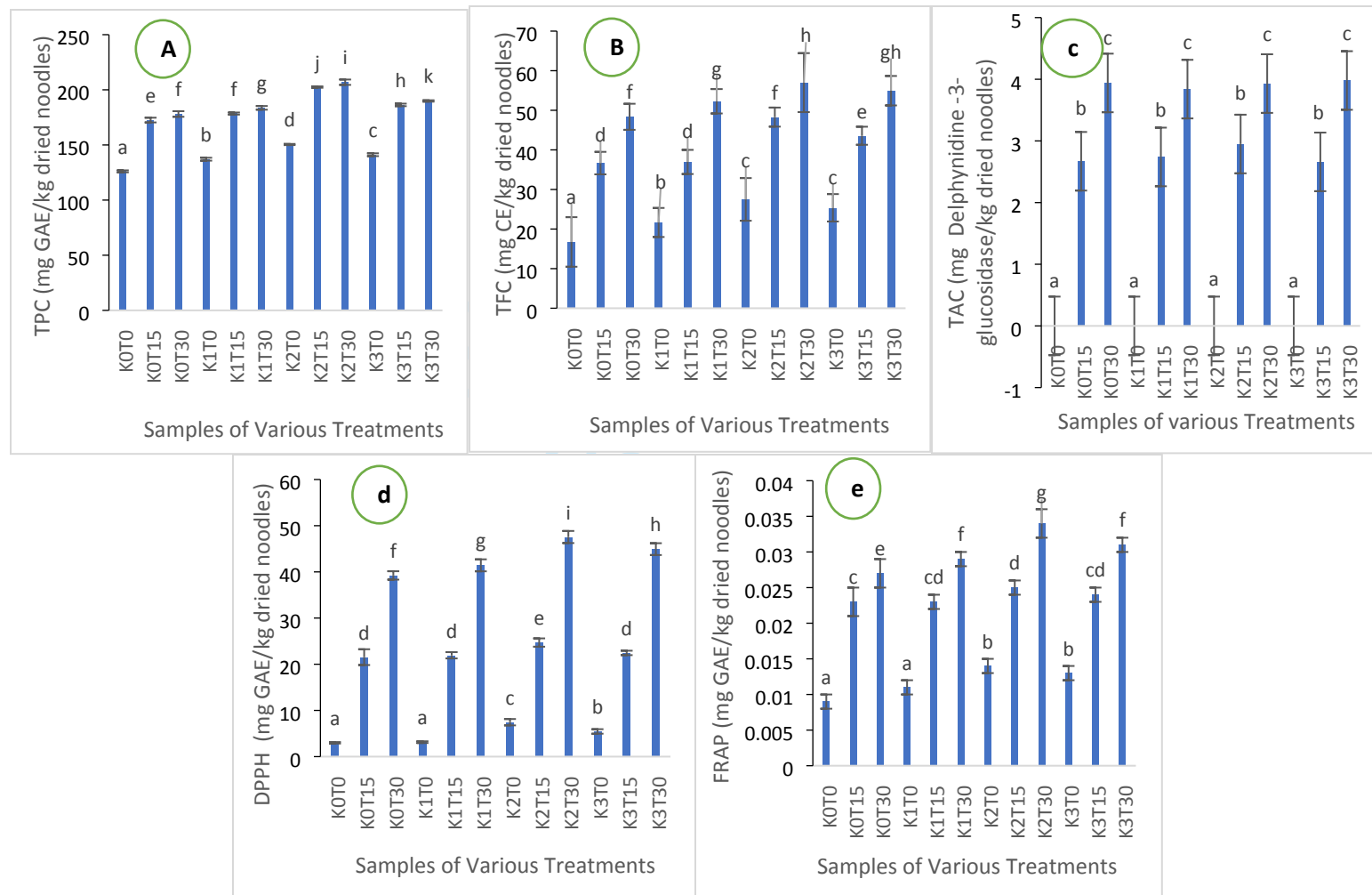
(b)

(c)



(d)

(e)



**Figure 5.** Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.055\%$ .

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

Table 4. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.055\%$ .

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Table 1. Formula of wet noodles

Treatment	Code	Ingredients					Composite flour (g)
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)		
1	K0T0	3	30	30	0	150	
2	K0T15	3	30	0	30	150	
3	K0T30	3	30	0	30	150	
4	K1T0	3	30	30	0	150	
5	K1T15	3	30	0	30	150	
6	K1T30	3	30	0	30	150	
7	K2T0	3	30	30	0	150	
8	K2T15	3	30	0	30	150	
9	K2T30	3	30	0	30	150	
10	K3T0	3	30	30	0	150	
11	K3T15	3	30	0	30	150	
12	K3T30	3	30	0	30	150	

Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (% w/w). K1 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:19:1 (% w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:18:2 (% w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (% w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15 %. T30 = concentration of the butterfly pea extract = 30 %.

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K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
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K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: No significant effect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles at  $p \leq 0.05$ .

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

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K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

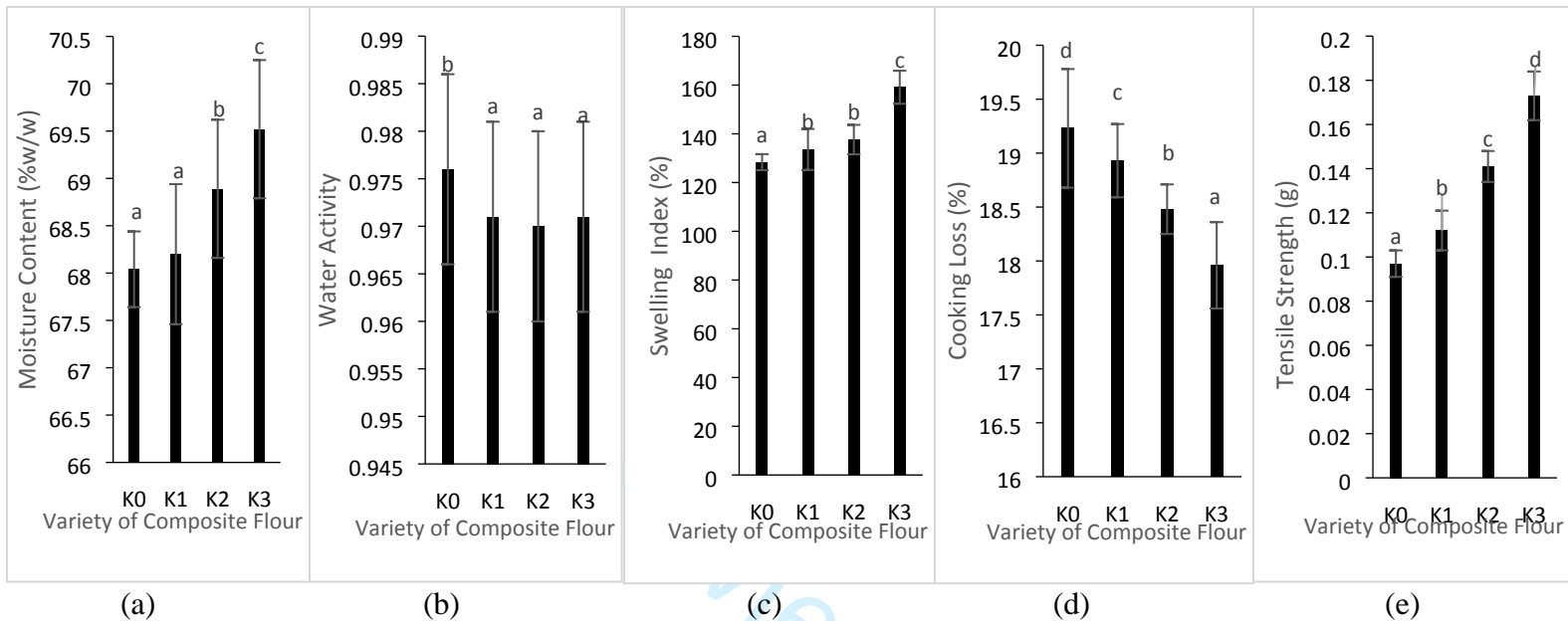


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

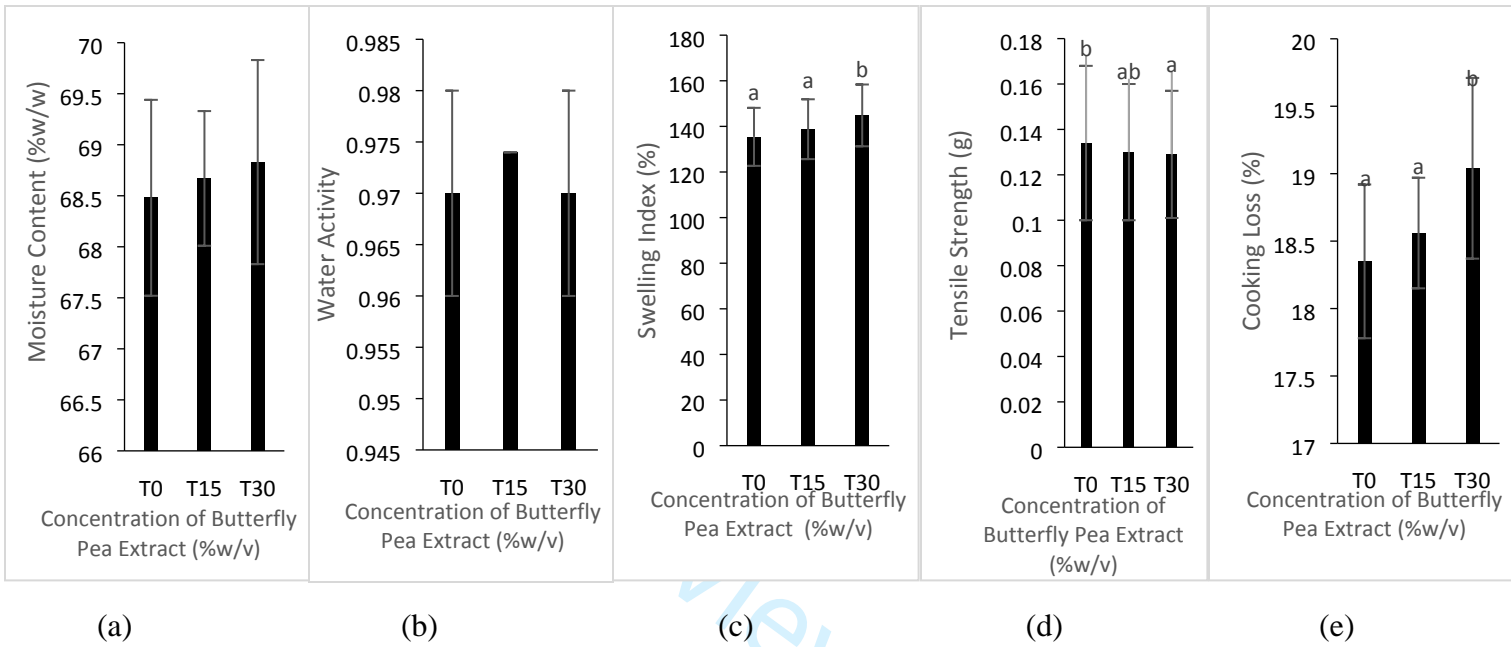


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

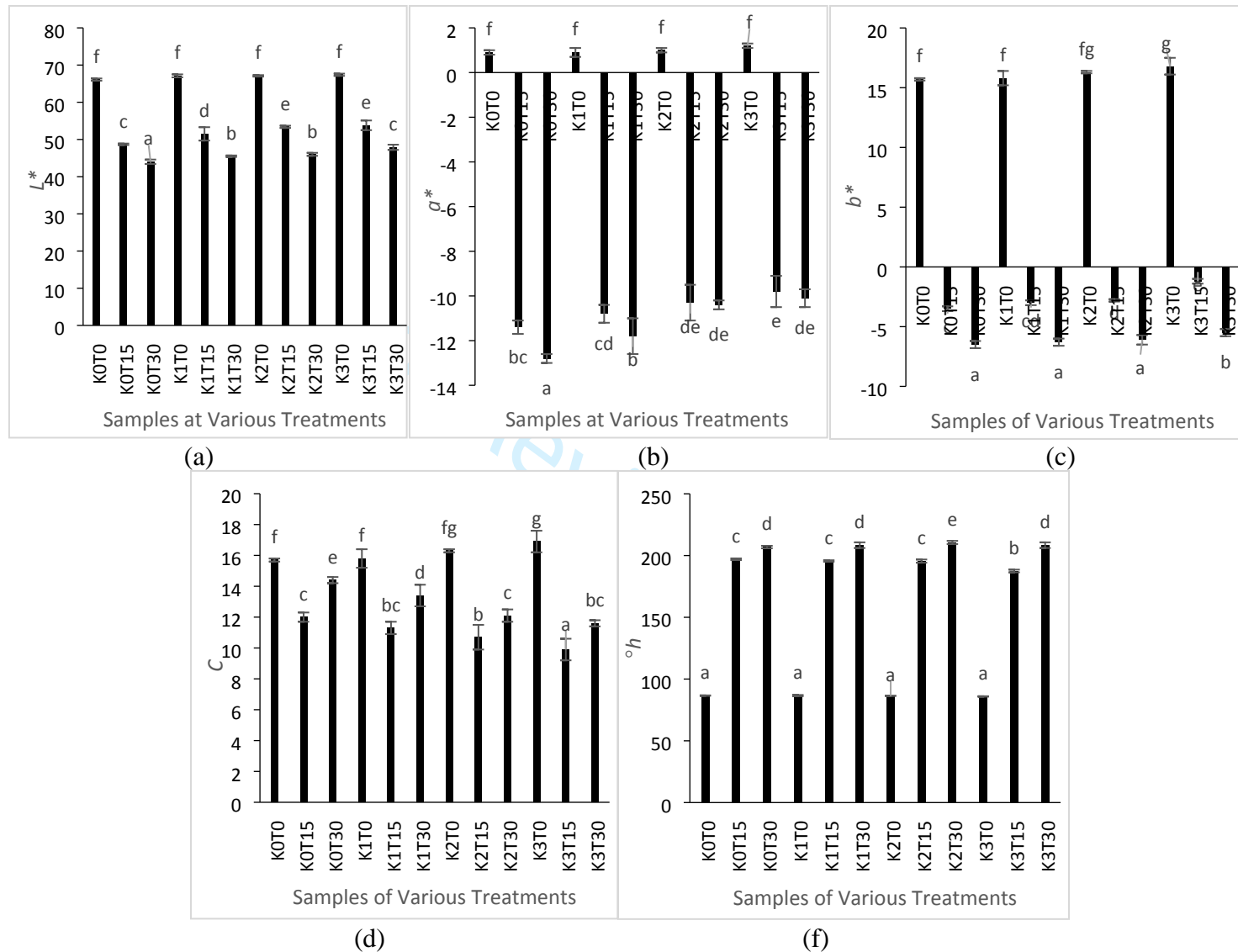


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

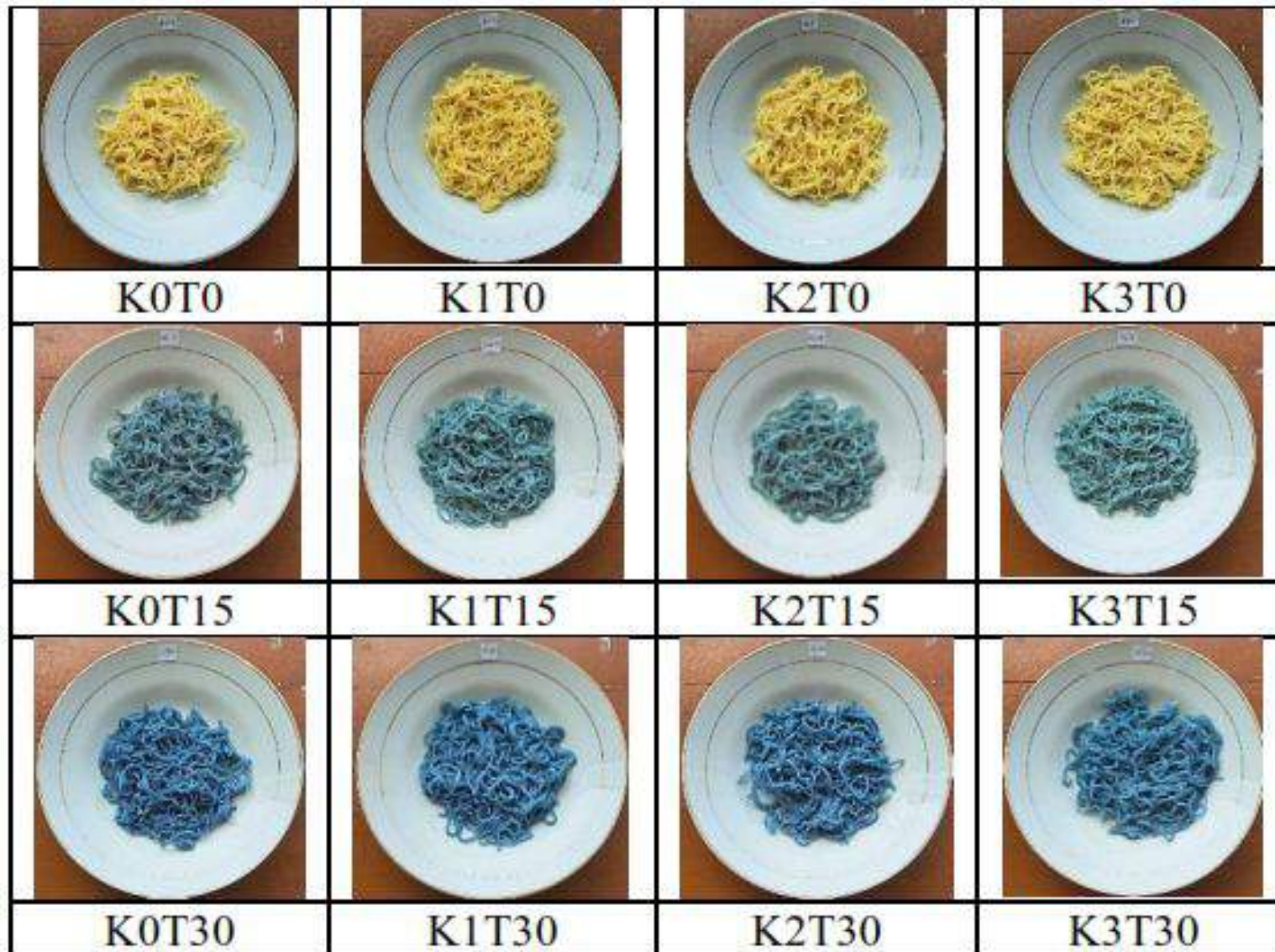


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract



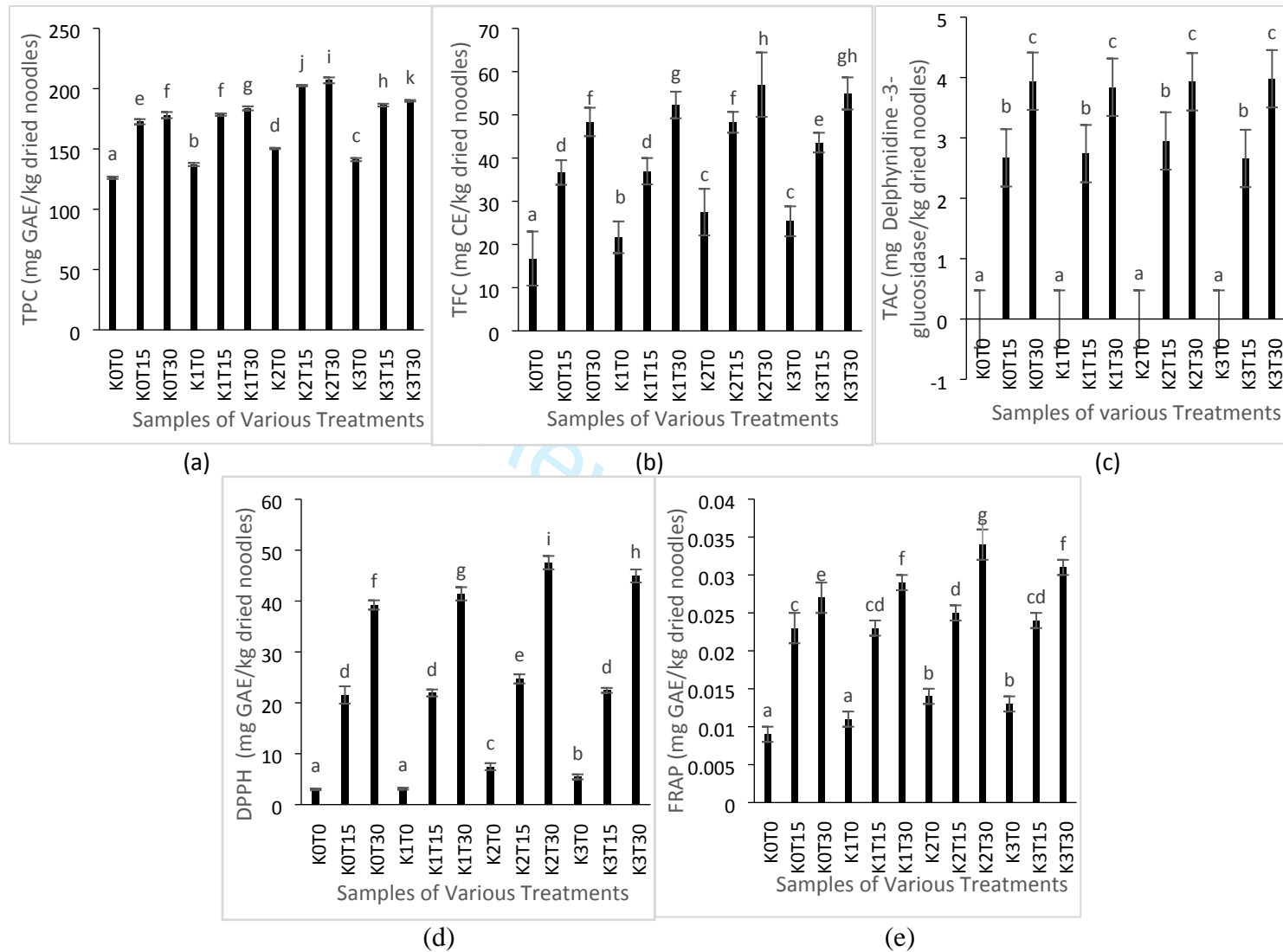


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

For Review Only

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Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Reminder: Beverage Plant Research**

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Mon, Oct 23, 2023 at 12:39 PM

Reply-To: bpr@maxapress.com

To: paini@ukwms.ac.id

23-Oct-2023

Dear Dr. Widyawati:

Recently, you received a decision on Manuscript ID BPR-S2023-0041, entitled "Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties and antioxidant activity of wet noodles." The manuscript and decision letter are located in your Author Center at <https://mc03.manuscriptcentral.com/bevpr>.

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Sat, Nov 4, 2023 at 9:55 PM

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04-Nov-2023

Dear Dr. Widyawati:

Your manuscript entitled "Effect of butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions" has been successfully submitted online and is presently being given full consideration for publication in the Beverage Plant Research.

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Sat, Nov 4, 2023 at 12:37 PM

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04-Nov-2023

Dear Dr. Widyawati:

Recently, you received a decision on Manuscript ID BPR-S2023-0041, entitled "Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties and antioxidant activity of wet noodles." The manuscript and decision letter are located in your Author Center at <https://mc03.manuscriptcentral.com/bevpr>.

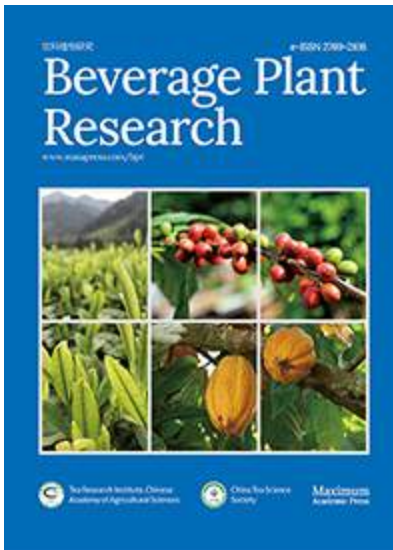
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**Effect of butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions**

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Keywords:	composite flour, butterfly pea flower, quality, sensory, wet noodles

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1 **Effect of composite flour proportion and butterfly pea (*Clitoria ternatea*) flower extract to**  
2 **qualities, sensory properties and antioxidant activity of wet noodles**

3  
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11

12

**Abstract**

13 The improving of wet noodles qualities, sensory and functional properties were done by  
14 using the composite flour base added with the butterfly pea flower extract. The composite flour  
15 of wheat flour, stink lily flour and  $\kappa$ -carrageenan at various ratio of 80:20:0 (K0), 80:19:1 (K1),  
16 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentration of butterfly pea extract  
17 of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed randomized block design with 2  
18 factors, namely the composite flour and the concentration of butterfly pea flower extract that  
19 resulted 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15,  
20 K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower  
21 extract were significantly affected the color, sensory properties, bioactive compounds, and  
22 antioxidant activity of wet noodles. However, each factor had significant influenced of the physical  
23 properties from wet noodles, such as moisture content, water activity, tensile strength, swelling  
24 index and cooking loss. The using of  $\kappa$ -carrageenan up to 3% (w/w) in composite flour increased  
25 moisture content, swelling index and tensile strength but reduced water activity and cooking loss.  
26 K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at ratio of  
27 80:17:3 (% w/w) was the best consumer acceptance based on hedonic sensory score.

28 **Keywords:** composite flour, butterfly pea flower, quality, sensory, wet noodles

29



## 30 **Introduction**

31 Composite flour is a mixture of flour and several types of flour from other ingredients,  
32 which usually come from several types of carbohydrate sources (tubers, legumes, cereals) with or  
33 without wheat flour<sup>[1,2]</sup>. The composite flour is made to obtain suitable material characteristics for  
34 the desired processed product to result certain functional properties<sup>[3]</sup>. The use of composite flour  
35 has been widely carried out to increase the functional values and set the physical, chemical and  
36 sensory quality of the wet noodles. Siddeeg et al.<sup>[4]</sup> uses wheat-sorghum-guar flour and wheat-  
37 millet-guar flour to improve acceptability of wet noodles. Efendi et al.<sup>[5]</sup> informed that potato  
38 starch and tapioca flour at ratio of 50:50 (% w/w) can update the functional values of wet noodles.  
39 Dhull & Sandhu<sup>[6]</sup> claimed that noodles made from a blend of fenugreek flour up to 7% with  
40 wheat flour can produce a good texture and consumer acceptance. Park et al.<sup>[7]</sup> utilizes the blended  
41 ratio of purple-colored wheat bran to increase quality and antioxidant activity of wet noodles.

42 Previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
43 composited with wheat flour to increase the functional values of noodles by increasing the  
44 biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and  
45 prolong gastric emptying time<sup>[8,9]</sup>. However, adding of stink lily flour in base noodles flour had  
46 limited on elasticity and tensile strength of wet noodles<sup>[10,11]</sup>. Then, the  $\kappa$ -carrageenan was added  
47 to improve the texture properties of wet noodles. Those components were a collaborates with  
48 glucomannan to form cross linking with glutenin and gliadin by intern and intra-molecular bonds  
49 leading to improving of noodle texture<sup>[12-14]</sup>. Widyawati et al.<sup>[15]</sup> explained that using of the  
50 composite flour consisted of wheat flour, stink lily flour and  $\kappa$ -carrageenan can look up swelling  
51 index, total phenolic content (TPC), total flavonoid content (TFC) and DPPH free radical  
52 scavenging activity that influences an effectivity of bioactive compounds on composite flour as

53 antioxidant of wet noodles. Therefore, addition of the other ingredient enriched phenolic  
54 compounds is done to increase functional values of composite flour as antioxidant. Czajkowska–  
55 González et al. [16] informed that elaborate of natural antioxidant sources enriched phenolic  
56 compounds can improve functional values of bread. Widyawati et al. [15] has added pluchea extract  
57 to increase TPC, TFC and DPPH free radical scavenging activity of wet noodles, but the weakness  
58 of wet noodle color is not attractive that it is necessary to look for other ingredients, one of which  
59 is butterfly pea flower.

60 Butterfly pea (*Clitoria ternatea*) is an herb plant, Fabaceae family, having various color  
61 flower, such as purple, blue, pink, and white [17]. This flower has phytochemical compounds which  
62 are benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids,  
63 flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides  
64 [20,21]. Anthocyanins of the butterfly pea flower has been used as natural color in many food  
65 products [22,23], one of them is wet noodles [24,25]. The phytochemical compounds, especially  
66 phenolic compounds, can influence the interaction among gluten, amylose and amylopectin  
67 depend on partition coefficients, keto-groups, double bonds (in the side chains), and the benzene  
68 ring [26]. This interaction involves covalent and non-covalent bonds of them which were influenced  
69 pH and determined hydrophilic-hydrophobic properties and protein digestibility [27]. Previous  
70 study has proven that the use of phenolic compounds from plant extract, such as pluchea leaf [15,28],  
71 gendarussa leaf (*Justicia gendarussa* Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31]  
72 establishes the quality, bioactive compounds, antioxidant activity and sensory properties of wet  
73 noodles. Shiau et al. [25] has utilized natural color of butterfly pea flower extract to make wet  
74 noodles base wheat flour that results the higher total anthocyanin, polyphenol, DPPH scavenging  
75 activity and reducing power than the control samples and the use of this extract can improve color

76 preference and reduce the cutting force, tensile strength, and extensibility of cooked noodles. Until  
77 now, the application of water extract of butterfly pea flowers in wet noodles has been commercially  
78 produced but the interactions among phytochemical compounds and ingredients of wet noodles  
79 base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) has not been studied.  
80 Therefore, the study was conducted to decide the effect of composite flour and butterfly pea flower  
81 extract to quality, bioactive content, antioxidant activity, and sensory properties of wet noodles.

## 82 **Materials and Methods**

### 83 **Raw materials and preparation**

84 Butterfly pea flower was obtained from Penjaringan Sari garden, Wonorejo, Rungkut,  
85 Surabaya, Indonesia. The flower was sorted, washed, dried by open sunlight, powdered using  
86 blender (Philips HR2116, PT Philips, Netherlands) for 3 min, sieved using a sieve shaker with 45  
87 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water  
88 extract of butterfly pea flower was obtained using hot water extraction at 95°C for 3 min to get  
89 three concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three  
90 composite flours proportion were prepared with a mixing of wheat flour (Cakra Kembar, PT  
91 Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok  
92 Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratio of  
93 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### 94 **Chemical and reagents**

95 The gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin and sodium carbonate  
96 were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin–  
97 Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium  
98 hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide,

99 chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA).  
100 Distillated water was purchased by local market (PT Aqua Surabaya, Surabaya, Indonesia).

### 101 **Wet noodles preparation**

102 Wet Noodles were prepared based on the modified formula of Panjaitan et al. [11] as shown  
103 in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with  
104 butterfly pea flower extract at various concentration. The salt, water, fresh whole egg was then  
105 added and kneaded to make dough by using a mixer machine (Oxone Master Series 600 Standing  
106 Mixer OX 851, China). The dough was sheeted and cut via rollers using cutting blades (Oxone  
107 OX355AT, China). Wet noodles were sprinkled with tapioca flour before heated in boiled water  
108 (100°C) with a ratio of raw noodles /water at 1:4 w/v for 2 min. Cooked wet noodles were coated  
109 with palm oil before subjected to measure the quality and sensory properties but the samples  
110 without cooking and oil coating were used to analyze the bioactive compounds and antioxidant  
111 activity.

### 112 **Extraction of bioactive compounds of wet noodles**

113 Wet noodles were extracted based on the method of Widyawati et al. [15]. Raw noodles  
114 were dried in cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at  
115 60°C for 2 h. The dried noodles were grinded using a chopper (Dry Mill Chopper Philips set HR  
116 2116, PT Philips, Netherlands). The 20 g of samples were mixed with 50 mL of solvent mixture  
117 (1:1 v/v of methanol /water) and stirred at 90 rpm in shaking water bath at 35°C for 1 h and  
118 centrifuged at 5000 rpm for 5 min to obtain the supernatant. The residue obtained was re-extracted  
119 in the extraction time for 3 intervals. Supernatant was evaporated using rotary evaporator (Buchi-  
120 rotary evaporator R-210, Germany) at condition of 70 rpm, 70°C, and 200 mbar to result  
121 concentrated wet noodles. Then, the extract was used for further analysis.

122

**123 Moisture content analysis**

124 Water content of cooked wet noodles was analyzed based on thermogravimetry method<sup>[32]</sup>.

125 1 g samples were weighed in weighing bottle and heated by drying oven at 105-110°C for 1 h, then

126 samples were weighed and measured moisture content after weight of samples was constant.

127 Moisture content is calculated based on the difference in sample weight before and after a constant

128 weight is reached divided by the initial sample weight expressed as a percentage of wet base.

**129 Water activity analysis**

130 Water activity of cooked wet noodles was analyzed using Aw-meter (Water Activity

131 Hygropalm HP23 Aw a set 40 Rotronic, Swiss). 10 g samples were weighed and entered in Aw

132 meter chamber, analyzed and data recorded<sup>[33]</sup>.

**133 Tensile strength analysis**

134 Tensile strength is essential parameter that measures extensibility of cooked wet

135 noodles<sup>[39]</sup>. 20 cm samples were measured tensile strength using texture analyzer that be equipped

136 by Texture Exponent Lite Program and used noodle tensile rig probe (TA-Xt Plus, Stable

137 Microsystem, UK). The noodle tensile rig was set to be pre-set speed, test speed, post-test speed 1

138 mm/s, 3 mm, 10 mm/s, respectively. Distance, time, and trigger force were used 100 mm, 5 sec

139 and 5 g, respectively.

**140 Color analysis**

141 10 g cooked wet noodles were weighed in chamber and analyzed color using color rider

142 (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[35]</sup>. Parameter measurement

143 was lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), Hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value is ranged 0-

144 100 that expressed brightness,  $a^*$  value shows red color which has an interval between -80 - +100.

145  $b^*$  value is yellow color that has an interval  $-70 - +70$  [36].  $C$  declares color intensity and  $^o h$  states  
146 color of samples [37].

#### 147 **Swelling index analysis**

148 Swelling index was determined on the modified method of Islamiya et al. [38]. 5 g raw wet  
149 noodles were weighed in chamber and cooked in 150 mL boiled water (100°C) for 5 min. The  
150 swelling index was analyzed to measure capability of raw wet noodles to absorb water that weight  
151 of raw wet noodles increased [39]. The swelling index was measured from difference in noodle  
152 weight before and after boiling.

#### 153 **Cooking loss analysis**

154 Cooking loss of raw wet noodles was analyzed on the modified method of Aditia et al. [40].  
155 The cooking loss expresses weight loss of wet noodles for cooking that is signed by the cooking  
156 water cloudy and thick [41]. 5 g raw wet noodles were weighed in chamber and cooked in 150 mL  
157 boiled water (100°C) for 5 min, then samples were drained and dried by drying oven at 105°C until  
158 the weight of the samples was constant.

#### 159 **Total phenolic content analysis**

160 Total phenolic content of wet noodles was determined using Folin-Ciocalteu's phenol  
161 reagent based on the modified method of Eyele et al. [42]. 50  $\mu\text{L}$  of extract was added 1 mL of 10%  
162 Folin-Ciocalteu's phenol reagent in 10 mL volumetric flask, shaken and incubated for 5 min.  
163 Then, 2 mL of 7.5 %  $\text{Na}_2\text{CO}_3$  was added and the volume was adjusted to 10 mL with distilled  
164 water. Solution was measured absorbance at  $\lambda$  760 nm (Spectrophotometer UV-Vis 1800,  
165 Shimadzu, Japan). The standard reference was used gallic acid and the result was expressed as mg  
166 GAE (Gallic Acid Equivalent) per kg of dried noodles.

167

**168 Total flavonoid content analysis**

169 Total flavonoid content was analyzed on the modified method using Li et al. [2013]. 250  $\mu\text{L}$   
170 of noodle extract was added with 0.3 mL of 5%  $\text{NaNO}_2$  and incubated for 5 min in a 10 mL  
171 volumetric flask. After 5 min of incubation, 0.3 mL of 10%  $\text{AlCl}_3$  was added. After 5 min, 2 mL  
172 of 1 M  $\text{NaOH}$  was added and the volume was adjusted to 10 mL with distilled water. Samples  
173 were mixed and homogenized before was analyzed using spectrophotometer (Spectrophotometer  
174 UV-Vis 1800, Shimadzu, Japan) at  $\lambda$ . 510 nm. The result was determined using (+)-catechin  
175 standard reference and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

**176 Total anthocyanin content analysis**

177 Total anthocyanin content was determined on the method of Giustl and Wrolstad [44]. 250  
178  $\mu\text{L}$  samples were added buffer solution at pH 1 and pH 4.5 in 10 mL test tube. And then each of  
179 samples was mixed and incubated for 15 min and measured at  $\lambda$  543 and 700 nm  
180 (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Absorbance (A) of samples was calculated  
181 with formula:  $A = (A_{\lambda 543} - A_{\lambda 700})_{pH 1.0} - (A_{\lambda 543} - A_{\lambda 700})_{pH 4.5}$ . The total anthocyanin  
182 content (mg/mL) was calculated by formula:  $\frac{A \times MW \times DF \times 1000}{\epsilon \times l}$ . Where A was absorbance, MW was  
183 molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was factor of sample dilution, and  
184  $\epsilon$  was absorptivity molar of delphinidin-3-glucoside ( $29000 \text{ L cm}^{-1} \text{ mol}^{-1}$ ).

**185 DPPH free radical scavenging activity**

186 DPPH scavenging activity was measured based on method of Shirazi et al. [45] and  
187 Widyawati et al. [46]. Briefly, 10  $\mu\text{L}$  extract was added to a 10 mL test tube containing 3 mL of  
188 DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room.  
189 Solution was centrifuged at 5000 rpm for 5 min and absorbance of samples was measured at  $\lambda$ .  
190 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant activity of samples was

191 stated as inhibition capacity with gallic acid as standard reference and expressed as mg GAE  
192 (Gallic Acid Equivalent) per kg of dried noodles.

### 193 **Ferric reducing antioxidant power**

194 FRAP analysis was used the modified method of Al-Temimi and Choundhary <sup>[47]</sup>. 50  $\mu$ L  
195 of extract in a test tube was added 2.5 mL of phosphate buffer solution at PH 6.6 and 2.5 mL of  
196 1% potassium ferric cyanide, shaken and incubated for 20 min at 50°C. After incubation 20 min,  
197 solution was added 2.5 ml of 10% mono chloroacetic acid and shaken. Then, 2.5 mL of supernatant  
198 was taken and added 2.5 mL of bi-distillated water and 2.5 mL of 0.1% ferric chloride and  
199 incubated for 10 min. After incubation, samples were measured absorbance at  $\lambda=700$  nm  
200 (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant capacity was used gallic acid  
201 as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

### 202 **Sensory evaluation**

203 Sensory properties of cooked wet noodles were analyzed on the modified method using  
204 Nugroho et al. <sup>[48]</sup> based on hedonic scale scoring, including color, aroma, taste, and texture  
205 attributes with 15 level, score 1 was stated very dislike and 15 was very like. This sensory analysis  
206 used 100 untrained panelists who had previously gained knowledge of the measurement procedure  
207 with ages between 17 until 25-year-old. The best treatment was determined by index effectiveness  
208 test.

### 209 **Design of experiment and statistical analysis**

210 Design of experiment used a randomized block design (RBD) with two factors, i.e., the  
211 four ratios of the composite flour (wheat flour, stink lily flour and  $\kappa$ -carrageenan) including  
212 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea  
213 flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was done in



214 three replications. The homogenous data of triplicate analysis was expressed as the mean  $\pm$  SD.  
215 The one-way analysis of variance (ANOVA) was done and Duncan's New multiple range test  
216 (DMRT) was used to determine for differences between means ( $p \leq 0.05$ ) using the statistical  
217 analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## 218 **Results and discussions**

### 219 **Quality of Wet Noodles**

220 Quality of wet noodles including moisture content, water activity, tensile strength, swelling  
221 index, cooking loss, and color was shown in Table 2 and Fig.1, 2, 3, and 4. Moisture content and  
222 water activity (AW) of raw wet noodles were only significantly influenced the various ratio of  
223 composite flour ( $p \leq 0.05$ ) (Fig. 1). However, the interaction of two factors, the difference in the  
224 ratio of composite flour and the concentration of butterfly pea extract or the concentration of  
225 butterfly pea extract itself, did not have a significant effect on the water content and AW of wet  
226 noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70 % wet base)  
227 compared to K0 (68 % wet base), K1 (68 % wet base), and K2 (69 % wet base) because the samples  
228 had the highest ratio of  $\kappa$ -carrageenan. The increasing of  $\kappa$ -carrageenan proportion influenced the  
229 amount of free and bound water in the wet noodle samples that increased the water content of wet  
230 noodles. Water content measures the amount of free and weakly bound water in the pores,  
231 intermolecular, and intercellular space of samples [15,28,49]. Protein networking between gliadin and  
232 glutelin forms a three-dimensional networking structure of gluten involving water molecule [50].  
233 The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of  
234 gluten network to stability gluten network that increases water binding capacity and retards the  
235 migration of water molecules [51,52].  $\kappa$ -carrageenan can bind water molecule around 25-40 times  
236 [53]. The  $\kappa$ -carrageenan can cause the structure change of gluten protein though electrostatic

237 interactions and hydrogen bonding <sup>[54,55]</sup>. Interaction among protein of wheat flour (gliadin and  
238 glutelin), glucomannan of stinky lily flour and  $\kappa$ -carrageenan also changed the conformation of  
239 the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds,  
240 intra-and inter-molecular disulfide bonds that is be able to establish water mobility in dough of  
241 this wet noodles. The effect of this interaction of all components of composite flour significantly  
242 influenced of the amount of free water ( $p \leq 0.05$ ) (Fig. 1). The addition of  $\kappa$ -carrageenan between  
243 1-3% in the wet noodle formulation reduced the AW about 0.005-0.006. The capability of  $\kappa$ -  
244 carrageenan absorbed water molecules reduces the water mobility in wet noodles due to the  
245 involving of hydroxyl, carbonyl, and ester sulphate groups of them to form complex structure <sup>[55-  
246 57]</sup>. The complexity of the reaction among components in wet noodles to form a three-dimensional  
247 networking influenced the amount of free water molecules that determined water activity values.  
248 The strength of the bonding among the components arranged of wet noodles and water molecules  
249 also specified the value of the water activity.

250 Tensile strength, swelling index, and cooking loss of cooked wet noodles was significant  
251 influenced by each factors of the composite flour or the concentration of butterfly pea flower  
252 extract ( $p \leq 0.05$ ) (Fig. 1 and 2), but the interaction of the various ratio of composite flour and the  
253 concentration of butterfly pea extract was not significant influenced the tensile strength, swelling  
254 index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). The increasing of the ratio of  $\kappa$ -  
255 carrageenan in composite flour increased the tensile strength and swelling index, and decreased  
256 cooking loss of wet noodles, but the increasing of the concentration of butterfly pea extract  
257 decreased the tensile strength and increased swelling index and cooking loss of wet noodles. The  
258 effect of the ratio of composite flour to the tensile strength ranged between 0.197 to 0.171 g. While  
259 the addition of butterfly pea extract caused the tensile strength of wet noodles (T15 and T30)

260 significant lower around 0.003 until 0.008 than control (K1). The highest swelling index values  
261 was owned by K3 sample and the lowest swelling index values were belonging of the K0 sample.  
262 The swelling index values of wet noodles ranged around 128 to 159 %. The effect of composite  
263 flour proportion of wet noodles showed that K0 sample had the highest cooking loss and K3 sample  
264 possessed the lowest cooking loss. While the effect of the concentration of butterfly pea extract  
265 resulted the lowest cooking loss values of T0 sample and the highest cooking loss values of T30  
266 sample. The cooking loss values of wet noodles ranged around 18 to 19 %.

267 Tensile strength, cooking loss and swelling index of wet noodles was clearly influenced by  
268 participation of components in dough formation, the interaction among glutelin, gliadin,  
269 glucomannan,  $\kappa$ -carrageenan and polyphenolic compounds resulted a three-dimensional network  
270 structure determined capability of resistance of the noodle strands to break and gel formation.  $\kappa$ -  
271 carrageenan is a high molecular weight hydrophilic polysaccharide composed hydrophobic 3,6-  
272 anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4)  
273 glycosidic linkages [58,59] that can bind water molecule to form gel. Glucomannan is soluble fiber  
274 with main chain  $\beta$ -1,4 linkage of D-glucose and D-mannose that can absorb water molecule around  
275 200 times [60] to form strong gel that increases viscosity and swelling index of dough [61]. Park and  
276 Baik [62] claimed that tensile strength of noodles is affected by gluten network formation. Huang  
277 et al. [55] also reported that  $\kappa$ -carrageenan can increase firmness and viscosity of samples because  
278 the water binding capacity of this hydrocolloid is very strong. Cui et al. [51] claimed that konjac  
279 glucomannan does not only stabilize the structure of gluten network but react free water molecule  
280 to form more stable of a three-dimensional networking structure, thus holding the rheological and  
281 tensile properties of dough.

282 The increasing of swelling index of dough is caused the capability of glucomannan to  
283 reduce pore size and increase the pore numbers with uniform size <sup>[63]</sup>. The synergistic interaction  
284 between these hydrocolloids and gluten protein results stronger, more elastic, and stable gel  
285 because of the association and lining up of the mannan molecules into the junction zones of  
286 helices<sup>[64]</sup>. The cross-linking and polymerization involving functional groups of gluten protein,  $\kappa$ -  
287 carrageenan and glucomannan determined binding force with each other. The stronger attraction  
288 between molecules composed cross-linking reduces the particles or molecules loss during  
289 cooking<sup>[64-66]</sup>. Stability of the network dimensional structure of protein was influenced by the  
290 interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in dough  
291 of wet noodles that determined tensile strength, swelling index and cooking loss of wet noodles.  
292 Schefer et al. <sup>[27]</sup> and Widyawati et al. <sup>[15]</sup> explained that phenolic compounds can disturb the  
293 interaction between protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to  
294 form a complex structure through many interactions, including hydrophobic, electrostatic, and Van  
295 der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly  
296 pea extract were interacted with  $\kappa$ -carrageenan, glucomannan, protein or polysaccharide and  
297 influenced complex network structure. The phenolic compounds can disrupt a three-dimensional  
298 networking of interaction among gluten protein,  $\kappa$ -carrageenan and glucomannan through  
299 aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of  
300 disulphide bridges to form of thiols radicals <sup>[65,66]</sup>. These compounds can form complexes with  
301 protein and hydrocolloids leading to structural and functional changes and influence gel formation  
302 though aggregation formation and disulphide bridges breakdown <sup>[26,27,67]</sup>.

303 Color of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction between  
304 the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with

305 increasing the ratio of composite flour and the concentration of butterfly pea extract. Most of color  
306 parameters values were lower than the control (K0T0, K1T0, K2T0, K3T0), except yellowness  
307 and chroma values of K2T0 and K3T0, whereas the increasing of amount of butterfly pea extract  
308 changed all color parameters. The ranging of  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $oh$  were about 44 to 67, -13 to 1,  
309 -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness and yellowness of wet noodles  
310 grew with going up the  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea  
311 flower extract. Chroma and hue of wet noodles decreased with increasing of  $\kappa$ -carrageenan  
312 proportion from T0 until T15, and then increased at T30. K2T30 treatment had the strongest blue  
313 color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -carrageenan in composite  
314 flour also supported water holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan  
315 was synergized with glucomannan to produce strong stable network that involved sulfhydryl  
316 groups. Tako and Konishi <sup>[68]</sup> reported that  $\kappa$ -carrageenan is capable to associate making polymer  
317 structure that involves intra- and intermolecular interaction, such as ionic bonding and  
318 electrostatic forces. The mechanism of making three-dimensional network structure that  
319 implicated all component of composite flour was very complicated because they involved polar  
320 and non-polar functional groups and many kinds of interaction of them. These were influenced  
321 water content and water activity of wet noodles that were impacted wet noodle color. The other  
322 cause of wet noodles was anthocyanin pigment from butterfly pea extract. Gamage et al. <sup>[69]</sup>  
323 reported that anthocyanin pigment of butterfly pea is delphinidin-3-glucoside having blue color.  
324 Increasing of extract concentration declined lightness, redness, yellowness and chroma as well as  
325 changed hue color from yellow to be green until blue color.

326 The effect of composite flour and butterfly pea extract on color was observed in chroma  
327 and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness,

328 but butterfly pea extract reduced the two parameters. Thanh et al. [70] and Padmawati et al. [71] also  
329 founded similarity of their research. Anthocyanin pigment of butterfly pea extract can be interacted  
330 with color of stinky lily and  $\kappa$ -carrageenan impacted color change of wet noodles. Thus, the sample  
331 T0 is yellow color, T15 is green color and T30 is blue color. Color intensity showed as chroma  
332 values of yellow values increased along with higher proportion of  $\kappa$ -carrageenan at the same  
333 concentration of butterfly pea extract, but the higher concentration of butterfly pea extract declined  
334 green and blue colors of wet noodles at the same proportion of composite flour. Wet noodle color  
335 also estimated to be influenced by the phenolic compound content which underwent  
336 polymerization or degradation during the heating proses. Widyawati et al. [28] reported that  
337 bioactive compounds in pluchea extract can change wet noodle color because of discoloration of  
338 pigment during cooking. K2T30 was wet noodles having strongest blue color due to different  
339 interaction of anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan that were  
340 capable to reduce intensity of blue color or chroma values.

341 **The content of phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) of wet**  
342 **noodles**

343 TPC, TFC and TAC were shown in Fig. 5. The TPC and TFC of wet noodles were  
344 significantly influenced by interaction between two parameters of the ratio of composite flour and  
345 the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and  
346 butterfly pea extract resulted the highest TPC and TFC. The K2T30 had the highest TPC and TFC  
347 as  $\sim 207$  mg GAE/kg dried noodles and  $\sim 57$  mg CE/kg dried noodles, respectively. While the  
348 TAC of wet noodles was only influenced by the concentration of butterfly pea extract, the increase  
349 in extract addition leading to an increase in TAC. The extract substitution at T30 was obtained  
350 about  $3.92 \pm 0.18$  mg delfidine-3-glucoside/kg dried noodles of TAC. Based on Pearson correlation,

351 TPC of wet noodles was strong and positive correlated with TFC at T0 treatment ( $r= 0.955$ ), T15  
352 treatment ( $r=0.946$ ), T30 ( $r=0.765$ ), while TPC of samples was weak and positive correlated with  
353 TAC at T0 treatment ( $r=0.153$ ) and T30 ( $r=0.067$ ), except the samples at T15 treatment had  
354 correlation coefficient  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated  
355 with quality properties and antioxidant activity (AOA). Dominant anthocyanin pigment from  
356 butterfly pea extract is delphinidin <sup>[72]</sup> around  $2.41 \text{ mg/g}$  samples <sup>[73]</sup> that has free more acyl groups  
357 and aglycone structure <sup>[74]</sup> and can be used as natural pigment. The addition of butterfly pea extract  
358 influenced the color of wet noodles. Anthocyanin is potential as antioxidant agent through free-  
359 radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway,  
360 and inflammatory cytokines signaling <sup>[75,76]</sup>. Nevertheless, butterfly pea extract also composes  
361 tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids,  
362 anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids,  
363 and flavonol glycosides (kaempferol, quercetin, myricetin, 6''-malonylstragalgin, phenylalanine,  
364 coumaroyl sucrose, tryptophan, and coumaroyl glucose) <sup>[20,21]</sup>, chlorogenic, gallic, p-coumaric  
365 caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids <sup>[74]</sup>, ternatin  
366 anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexen, 1-methyl-4(1-  
367 methylethylidene), hirsutene <sup>[77,78]</sup>, that contribute to have antioxidant activity <sup>[18,78]</sup>. *Clitoria*  
368 *ternatea* shows potential as antioxidant activity based on an antioxidant assays, such as 2,2-  
369 diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power  
370 (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen  
371 radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion  
372 chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6- sulphonic acid) (ABTS) radical  
373 scavenging and  $\text{Cu}^{2+}$  reducing power assays <sup>[78]</sup>. TPC and TFC of wet noodles increased along

374 with the higher proportion of glucomannan in composite flour and the higher concentration of  
375 butterfly pea extract. Zhou et al. [79] claimed that glucomannan in stinky lily has hydroxyl groups  
376 that can be reacted with Folin Ciocalteus's phenol reagent. Devaraj et al. [80] reported that 3,5-  
377 acetylalbulin is flavonoid compounds in glucomannan can be bound complexes with  $AlCl_3$ .

### 378 **Antioxidant activity of wet noodles**

379 The antioxidant activity (AOA) of wet noodles was determined using DPPH radical  
380 scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP) as shown in Fig. 5. The  
381 proportion of composite flour and concentration of butterfly pea extracts significantly affected the  
382 DPPH ( $p \leq 0.05$ ). The noodles had DPPH ranging from 3 to 48 mg GAE/kg dried noodles. The  
383 noodles including composite flour of K0 and K1 and without of butterfly pea extracts (K0T0 and  
384 K1T0) had lowest DPPH, while the samples containing composite flour K2 with butterfly pea  
385 extracts 30% (K2T30) had highest DPPH. Pearson correlation showed that TPC and TFC were  
386 strong and positive correlated with DPPH (Table 7). Correlated coefficient values ( $r$ ) between TPC  
387 and AOA at T0, T15 and T30 treatments were 0.893, 0.815, and 0.883, respectively. Whereas  $r$   
388 values between TFC and DPPH at T0 treatment were 0.883, at T15 treatment were 0.739, and at  
389 T30 treatment were 0.753. However, correlation coefficient values between TAC and AOA at T0,  
390 T15 and T30 treatments were 0.123, 0.127, and 0.194, respectively. Interaction among  
391 glucomannan, phenolic compounds, amylose, gliadin and glutelin in dough of wet noodles  
392 determined number and position of free hydroxyl groups of them that influenced TPC, TFC, and  
393 DPPH. Widyawati et al. [46] said that free radical inhibition activity and chelating agent of phenolic  
394 compounds depends on position of hydroxyl groups and conjugated double bond of phenolic  
395 structures. The values of TPC, TFC and DPPH increased with higher level of stinky lily flour and  
396  $\kappa$ -carrageenan proportion and butterfly pea extract significantly up to 18 and 2% (w/w)



397 glucomannan and  $\kappa$ -carrageenan and 15% (w/w) extract, but the using of 17 and 3% (w/w)  
398 glucomannan and  $\kappa$ -carrageenan and 30% (w/w) extract showed a significant decrease. This  
399 showed that the use of stinky lily flour and k-carrageenan with a ratio of 17:3% (w/w) was able to  
400 reduce free hydroxyl groups which had the potential as electron or hydrogen donors in testing  
401 TPC, TFC and DPPH.

402 FRAP of wet noodles was significantly influenced by the interaction of two parameters of  
403 the proportion of composite flour and concentration of butterfly pea extracts ( $p \leq 5\%$ ). FRAP was  
404 used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ion to be  $\text{Fe}^{2+}$  ion. FRAP  
405 capability of wet noodles was lower than DPPH ranging 0.01 to 0.03 mg GAE/kg dried noodles.  
406 The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had lowest FRAP, while the  
407 samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest  
408 FRAP. Pearson correlation values showed that TPC dan TFC at T0 and T30 treatments had strong  
409 and positive correlated to FRAP activity, but T15 treatment possessed weak and positive  
410 correlation (Table 7). Correlation coefficient (r) values of TAC at T0 treatment was weak and  
411 positive correlated to FRAP samples, but r values at T15 and T30 treatments owned weak and  
412 negative correlation (Table 3). The correlation between DPPH and FRAP activities was obtained  
413 that DPPH method was highly correlated with FRAP method at T0 and T30 treatments and lowly  
414 correlated at T15 treatment (Table 3). Based on DPPH and FRAP methods showed that capability  
415 of wet noodles to scavenge free radical was higher than them to reduce ferric ion. It proved that  
416 bioactive compounds of wet noodles were more potential as free radical scavengers or hydrogen  
417 donors than as donor electron. Compounds that have capability to reducing power can act as  
418 primary and secondary antioxidant [81,82]. Poli et al. [83] said that bioactive compounds acted as  
419 DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless,

420 Suhendy et al. <sup>[84]</sup> claimed that a secondary antioxidant is natural antioxidant that has capability to  
421 reduce ferric ion (FRAP). Based on AOA assay, the results showed that phenolic compounds  
422 indicated strong and positive correlation with flavonoid compounds because of they are major  
423 phenolic compounds that are potential as antioxidant activities pass through highly effective  
424 scavenger of various free radicals. The effectivity of flavonoid compounds to inhibit free radicals  
425 and chelating agents is influenced by number and position of hydrogen groups and conjugated  
426 diene at A, B, and C rings <sup>[85-87]</sup>. Previous studies have proven that TPC and TFC exhibit significant  
427 contributor to scavenge free radicals <sup>[88-90]</sup>. However, TAC showed a weak correlation with TFC,  
428 TPC or AOA, although Choi et al. <sup>[89]</sup> stated that TPC and anthocyanins have a significant and  
429 positive correlation with AOA but anthocyanins were insignificantly correlated with AOA.  
430 Different structure of anthocyanins in samples determines AOA. Polymer anthocyanins or  
431 anthocyanin complexed with other molecules assign capability of them to electron or hydrogen  
432 donors. Martin et al. <sup>[91]</sup> informed that the anthocyanins are major groups of phenolic pigments  
433 that are an essential antioxidant activity depend on a steric hindrance of their chemical structure,  
434 such as number and position of hydroxyl groups and the conjugated doubles bonds, as well as the  
435 presence of electron in the structural ring. However, TPC and TFC at T0 and T30 treatments were  
436 highly and positive correlated with FRAP assay due to the role of phenolic compounds involved  
437 reducing power that contributed them to donor electron. Paddayappa et al. <sup>[82]</sup> reported that the  
438 phenolic compounds are capable to embroiled redox activities with action as hydrogen donor and  
439 reducing agents. The weakly relationship between TPC or TFC or DPPH and FRAP in the T15  
440 treatment suggested that there was an interaction between the functional groups in the benzene  
441 ring in phenolic and flavonoid compounds and the functional groups in components in composite  
442 flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

## 443 **Sensory Evaluation**

444           Sensory properties of wet noodles based on hedonic method, showed that composite flour  
445 and butterfly pea extract additions significantly influenced color, aroma, taste, and texture  
446 preferences ( $p \leq 0.05$ ) (Table 4). The preference values of color, aroma, taste, and texture attributes  
447 of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. The using of butterfly  
448 pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet  
449 noodles. Anthocyanin of butterfly pea extract gave different intensity of wet noodle's color that  
450 resulted color degradation from yellow, green until blue color impacted color preference of wet  
451 noodles. Nugroho et al. <sup>[48]</sup> also informed that addition of butterfly pea extract upgraded preference  
452 of panelist to dried noodles. Aroma of wet noodles was also affected by two parameters of  
453 treatments, the results showed that the higher proportion of stinky lily caused the stronger musty  
454 smell of wet noodles. Utami et al. <sup>[92]</sup> claimed that oxalic acid of stinky lily flour contributes to  
455 odor of rice paper. Therefore, a high proportion of k-carrageenan can reduce the proportion of  
456 stink lily flour, thereby increasing the panelist's preference for aroma. Sumartini and Putri <sup>[93]</sup>  
457 informed that panelist is more like noodles substituted the higher  $\kappa$ -carrageenan. Kurniadi et al.  
458 <sup>[94]</sup> and Widyawati et al. <sup>[15]</sup> said that  $\kappa$ -carrageenan is odorless material which doesn't result aroma  
459 of wet noodles. Neda et al. <sup>[77]</sup> added that volatile compounds of butterfly pea extract can mask  
460 musty smell of stinky lily flour, such as pentanal and mome inositol, Padmawati et al. <sup>[71]</sup> informed  
461 that they can gave sweet and sharp aroma. Taste preference of panelist to wet noodles without  
462 butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin <sup>[95]</sup> due to Maillard  
463 reaction of stinky lily flour processing. Nevertheless, using of butterfly pea extract at higher  
464 concentration of wet noodles increased bitter taste related to tannin compounds in this flower, this  
465 is supported by Hasby et al. <sup>[96]</sup> and Handayani and Kumalasari <sup>[97]</sup>. Effect of composite flour

466 proportion and butterfly pea extract also appeared to texture preference of wet noodles. Panelist  
467 was likely wet noodles that was not break up easily that K3T0 samples were chewy and elastic wet  
468 noodles, this was supported by tensile strength of wet noodles because of the different  
469 concentration of butterfly pea extract. The addition butterfly pea extract at higher concentration  
470 resulted sticky, break easy and less chewy wet noodles <sup>[26,27,85,97]</sup> due to competition among  
471 phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with  
472 water molecules to form gel <sup>[98]</sup>. Based on index effectiveness test, the noodles including composite  
473 flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment with total score of  
474 1.0504.

#### 475 **Conclusions**

476 Using of composite flour containing wheat flour, stinky lily flour and  $\kappa$ -carrageenan and  
477 butterfly pea extract influenced quality, bioactive compounds, antioxidant activity, and sensory  
478 properties of wet noodles. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -  
479 carrageenan and phenolic compounds determined a three-dimensional network structure that  
480 impacted moisture content, water activity, tensile strength, color, cooking loss, and swelling index,  
481 bioactive content, antioxidant activity, and sensory properties. The higher concentration of  
482 hydrocolloid addition caused increasing of water content and swelling index and decreasing of  
483 water activity and cooking loss. Addition of butterfly pea extract improved color, bioactive content  
484 and antioxidant activity and repaired panelist preference of wet noodles. Glucomannan of stinky  
485 lily flour and bioactive compounds of butterfly pea extract were able to increase the functional  
486 value of resulting wet noodles.

487

488

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## 492 **Conflict of Interest**

493 The authors declare no conflict of interest

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815 Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

816 Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink  
817 lily flour:  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan =  
818 80:18:2 (%w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 =  
819 concentration of the butterfly pea extract = 0%. T15= concentration of the butterfly pea extract =  
820 15%. T30 = concentration of the butterfly pea extract = 30%.

Table 2. Quality properties of wet noodles at the various ratio of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: Effect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles.

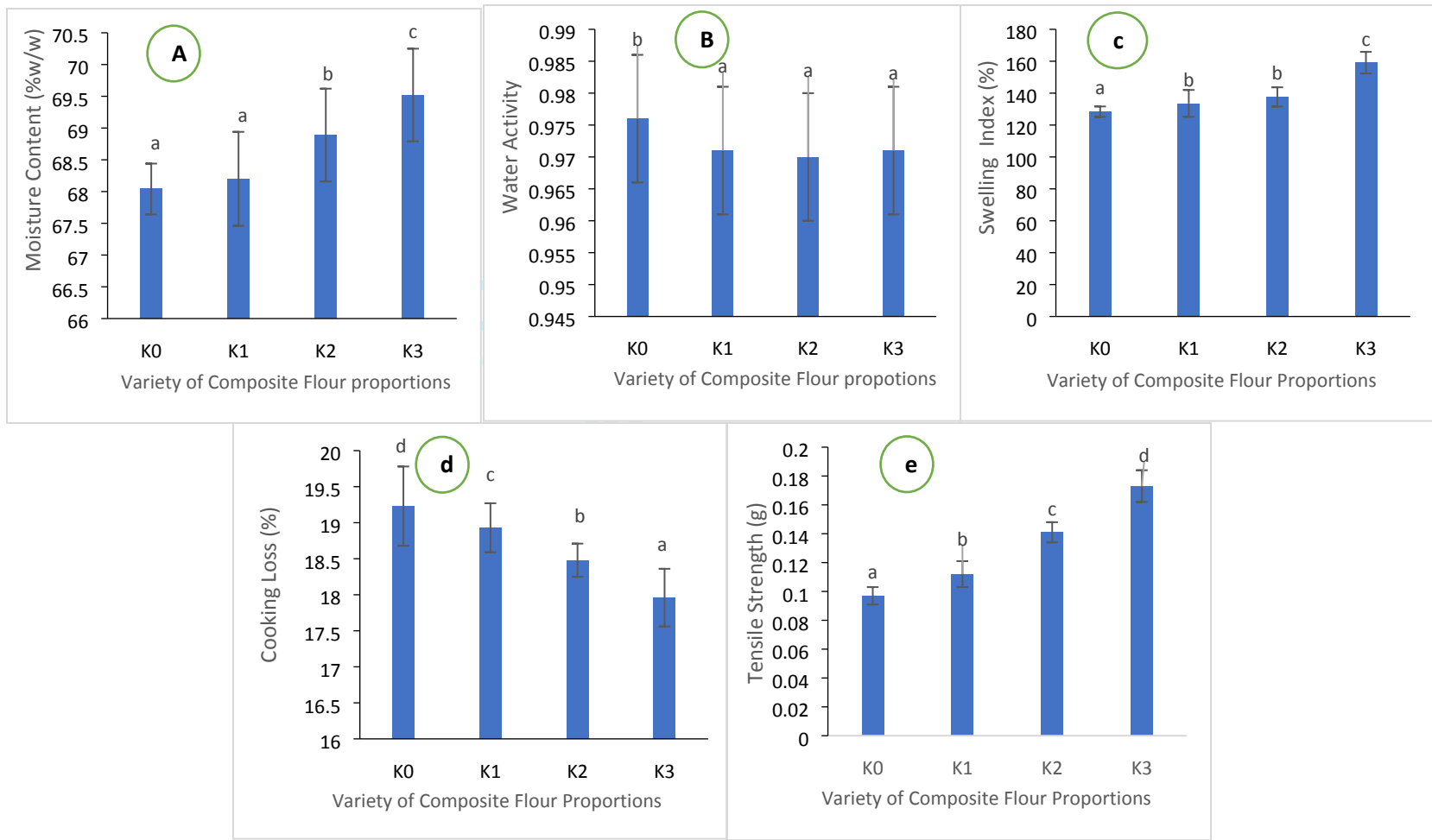


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

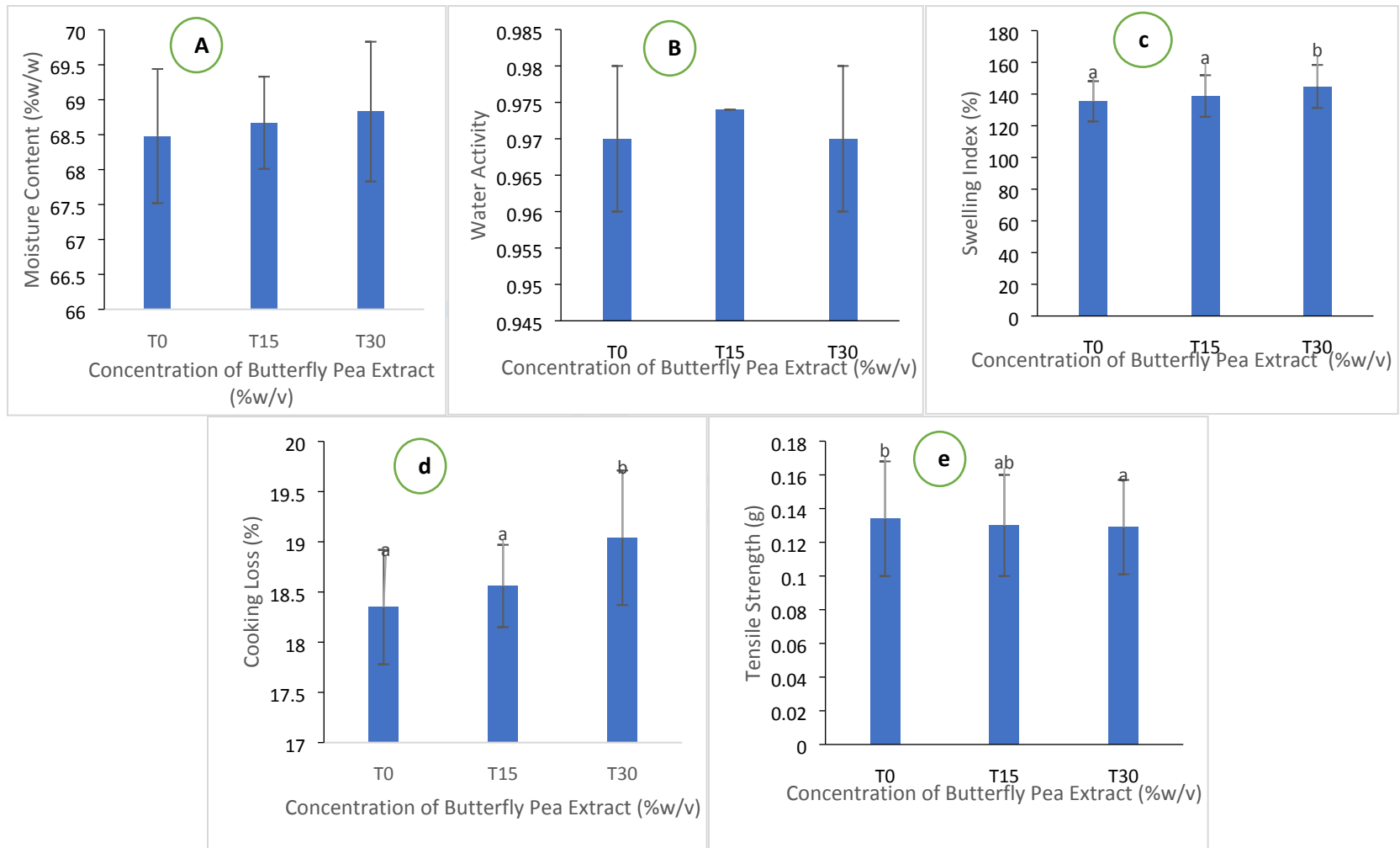


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

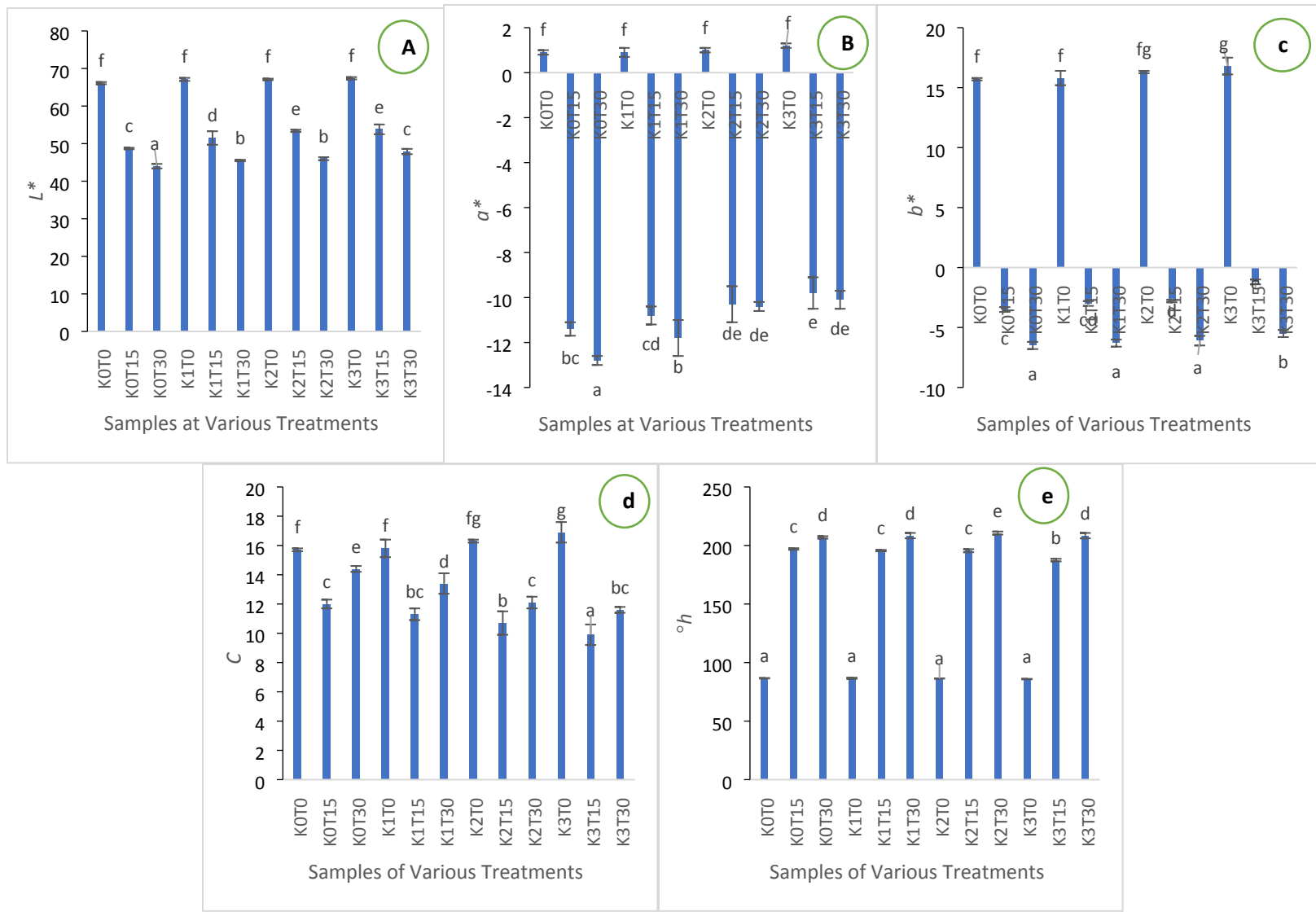


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .



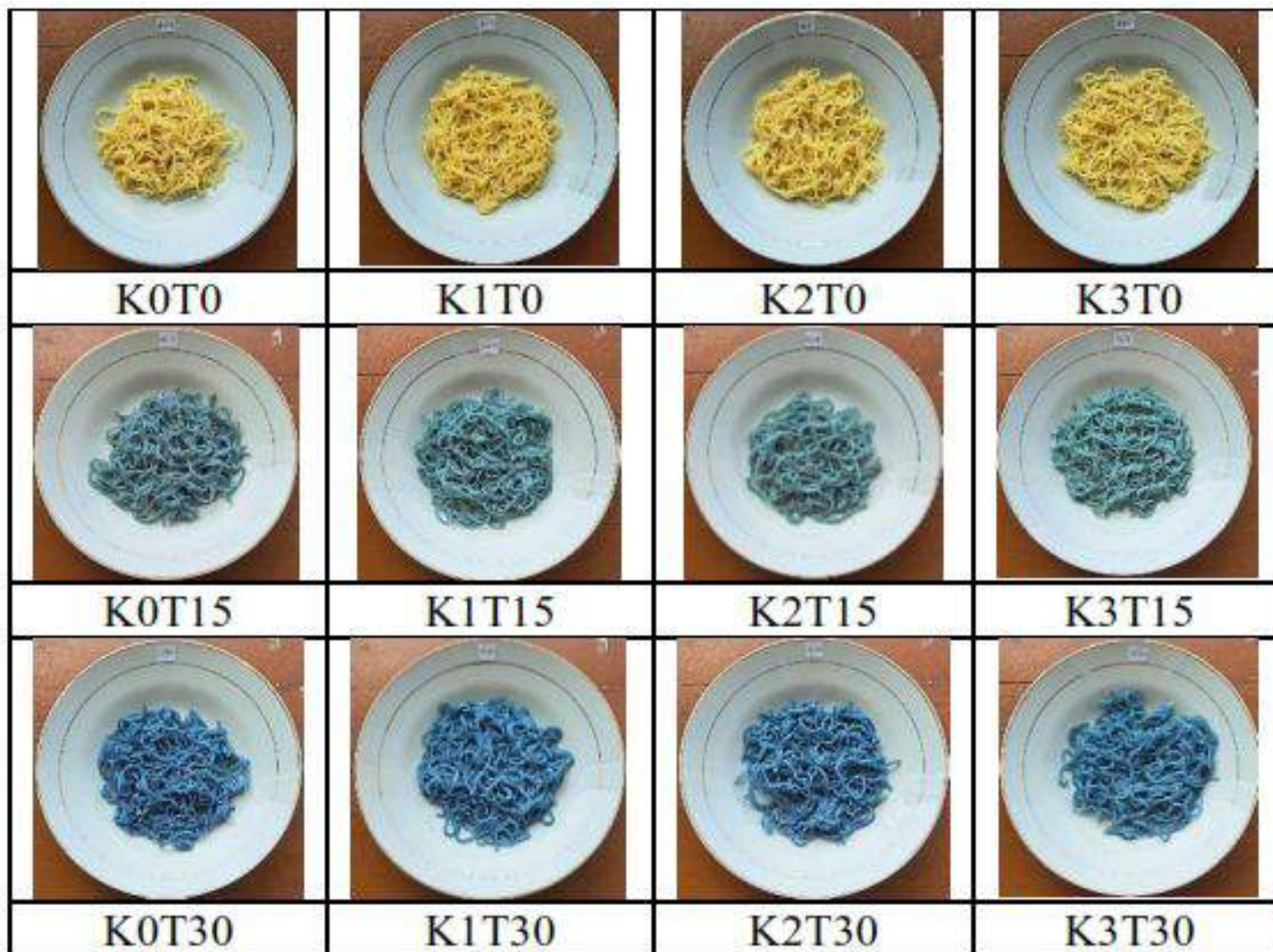


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

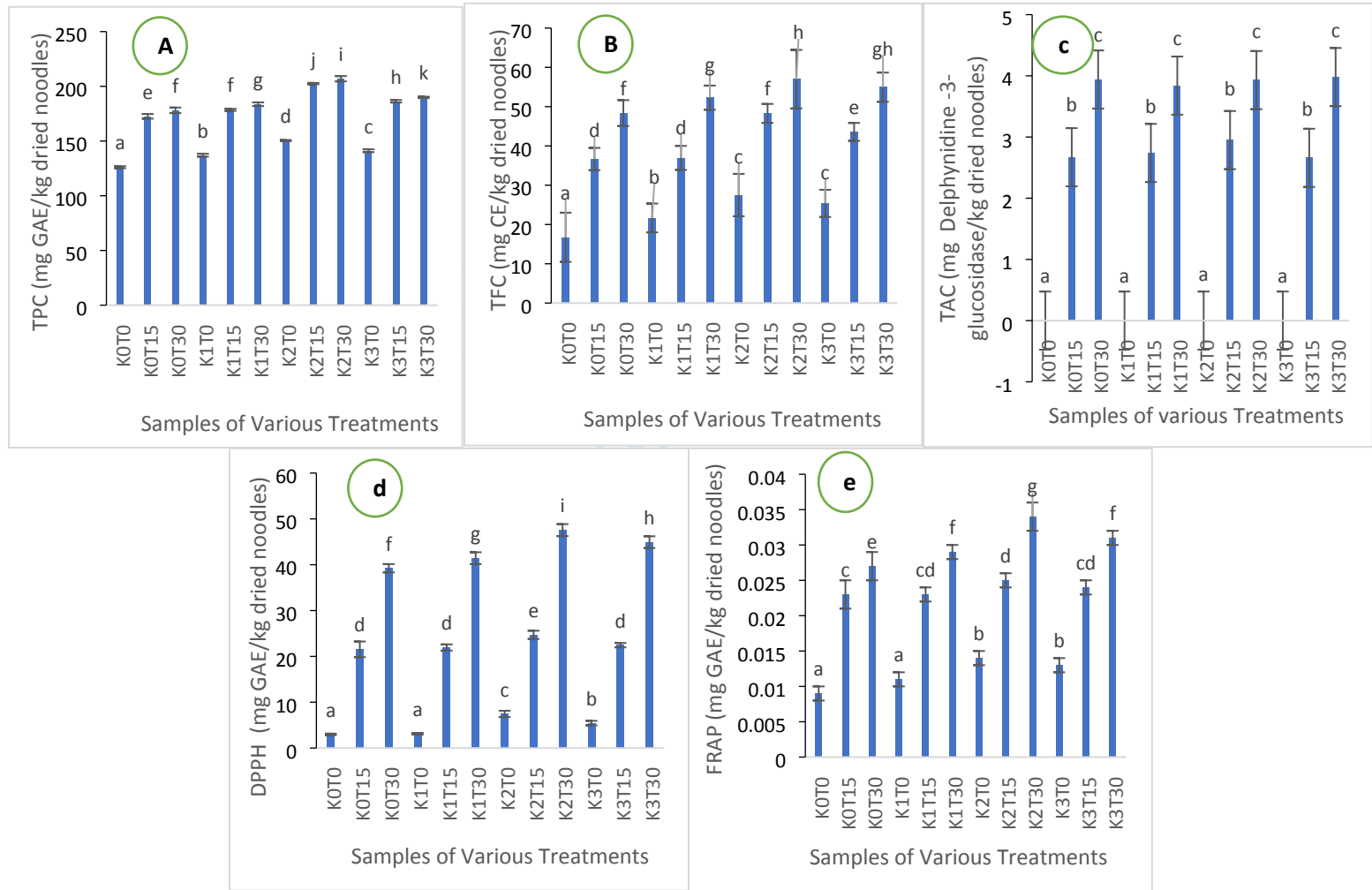


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

Table 4. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

For Review Only

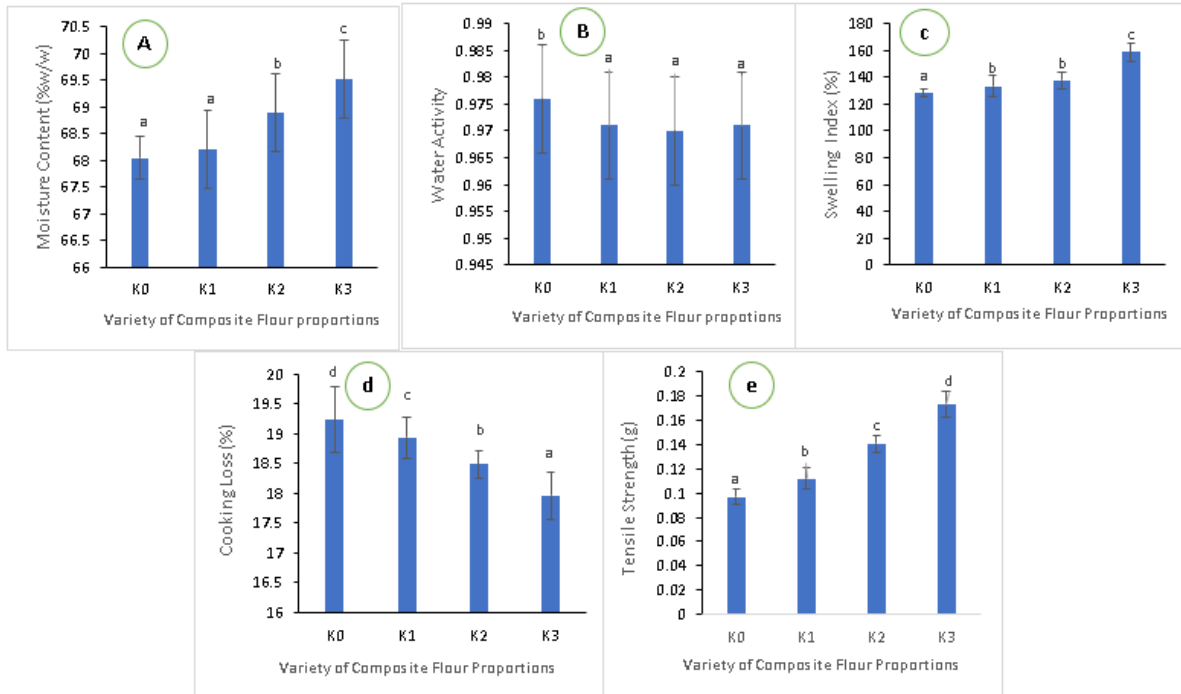


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

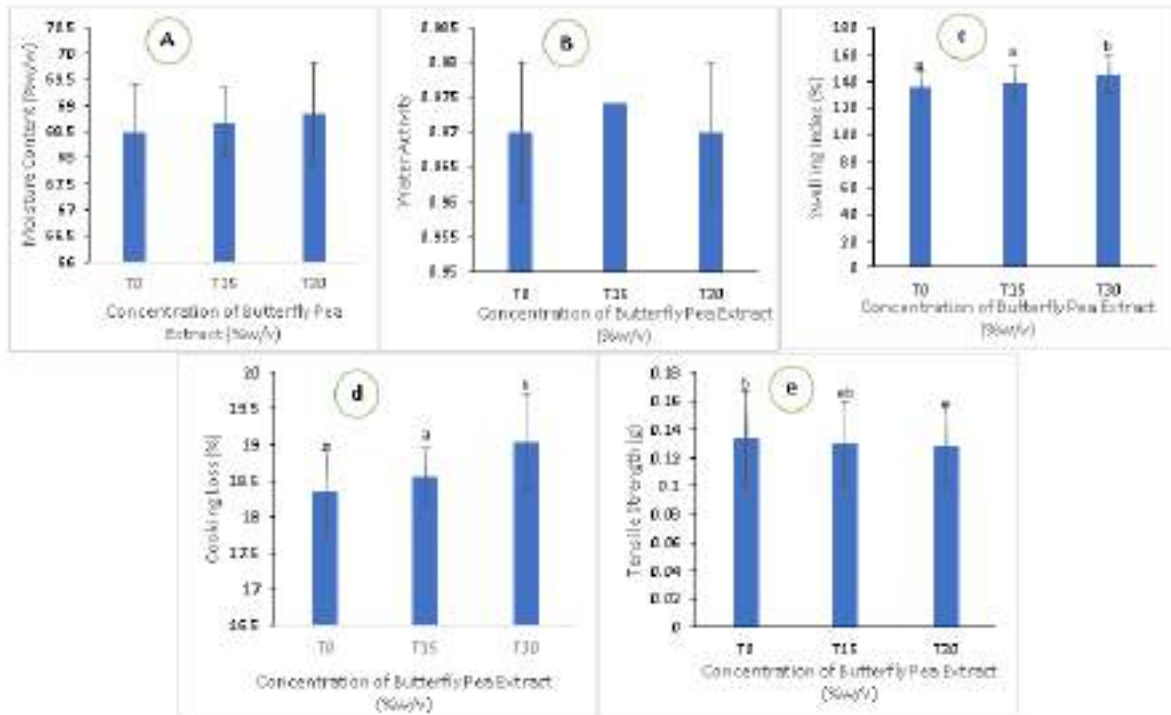


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

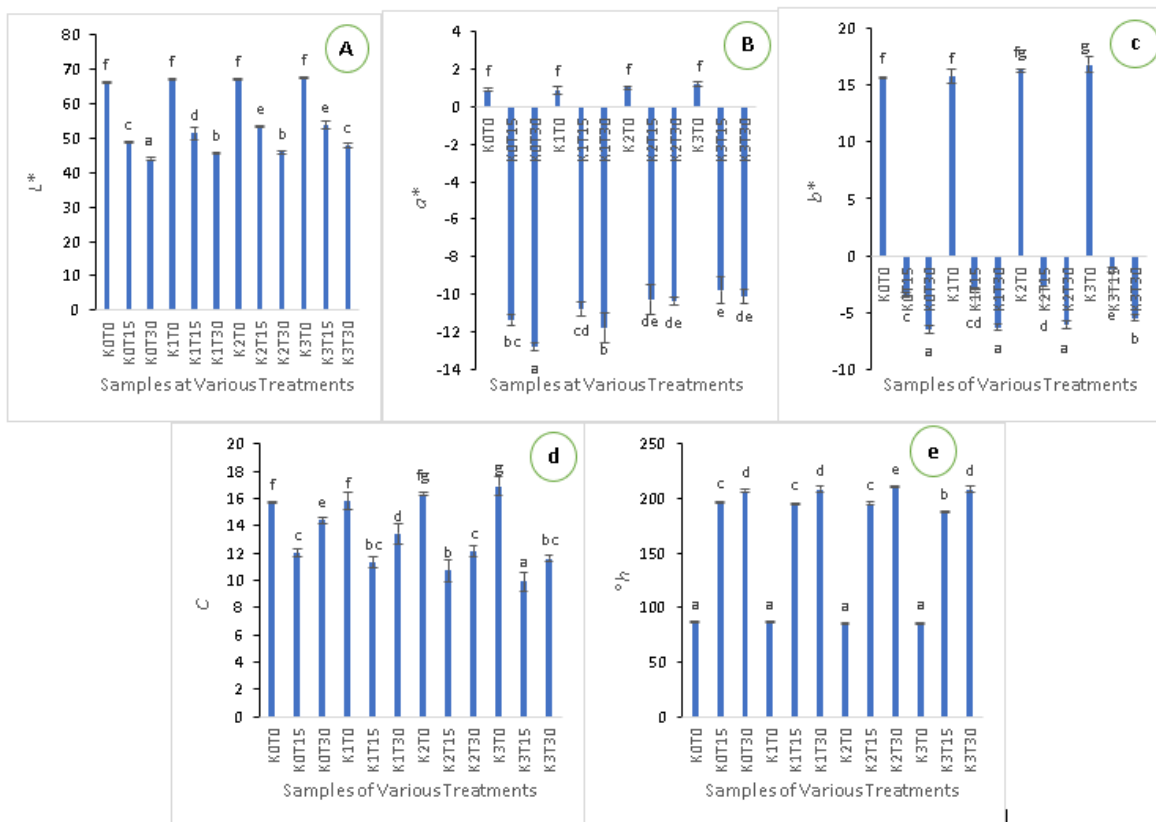


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .



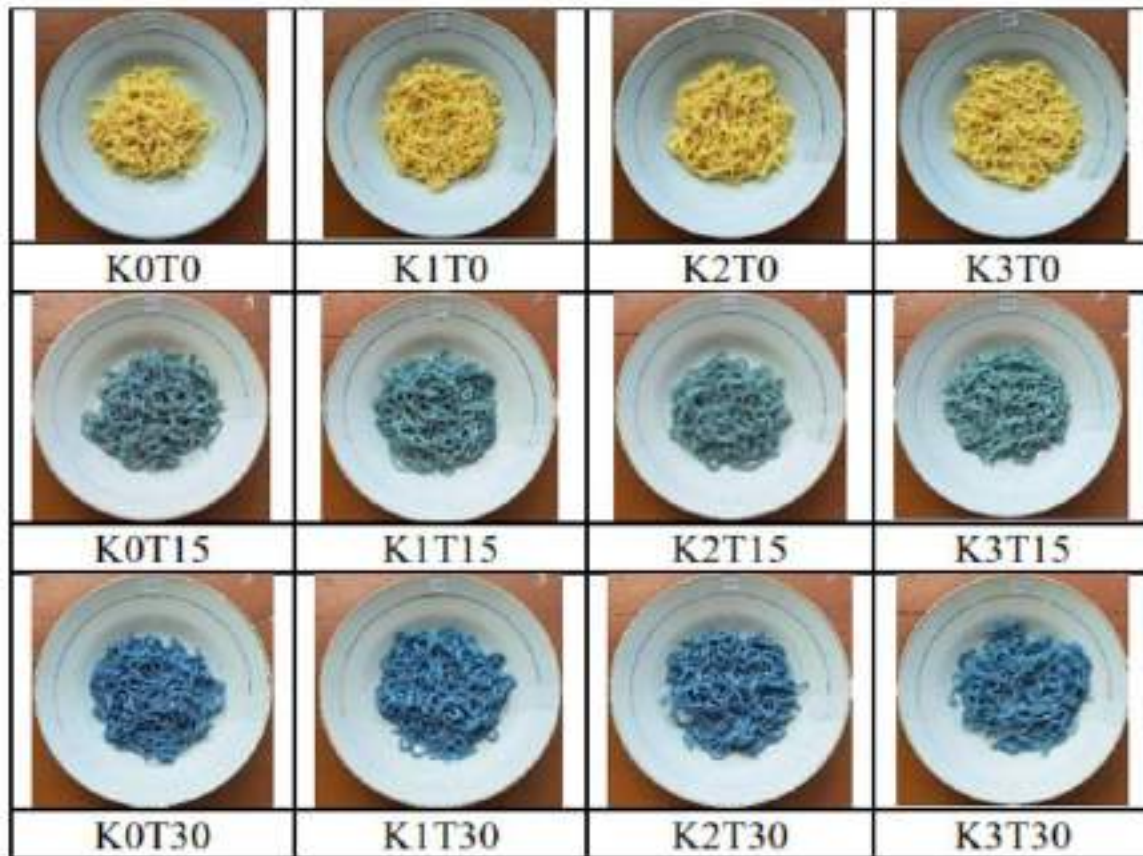


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract.

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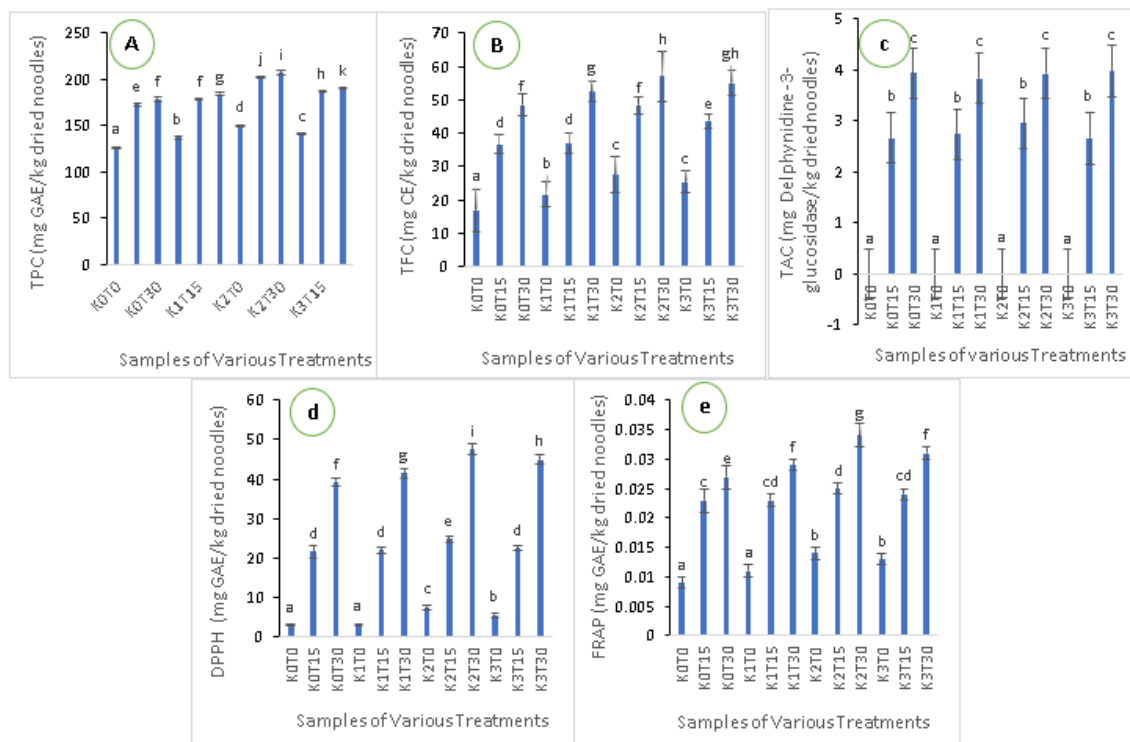


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 5\%$ .

Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

Table 2. Quality properties of wet noodles at the various ratio of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: Effect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles.

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	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

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Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
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K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 5\%$ .

3. Second Review: Major Revision (8-12-2023)

-Correspondence

-Decision Letter

-Document



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Beverage Plant Research - Decision on Manuscript ID BPR-S2023-0041.R1**

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Fri, Dec 8, 2023 at 12:21 PM

Reply-To: bpr@maxapress.com

To: paini@ukwms.ac.id

08-Dec-2023

Dear Dr. Widyawati:

Thank you for submitting to the Beverage Plant Research.

Manuscript ID BPR-S2023-0041.R1 entitled "Effect of butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions" has been reviewed. The comments of the reviewer(s) are included at the bottom of this letter.

The reviewer(s) and I have concerns that will require a major revision of your manuscript. Please evaluate the comments carefully and if you feel you can address the issues, we would welcome a revision.

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- A rebuttal letter;
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- Figures with a resolution of 300 dpi or above are expected;
- Supplementary files (Word or Excel) are anticipated.

Because we are trying to facilitate timely publication of manuscripts submitted to the Beverage Plant Research, we recommend a 4-week deadline for the submission of revised manuscript (Please Note: The exact cutoff time is 00:00 EST on 08-Jan-2024). If submitting your revision within a reasonable timeframe is not feasible for you, feel free to reach out to us to request an extension for the submission deadline.



Once again, thank you for submitting your manuscript to the Beverage Plant Research and I look forward to receiving your revision.

Sincerely,  
Prof. Zongmao Chen  
Editor-in-Chief  
Beverage Plant Research

Reviewer(s)' Comments to Author:

Reviewer: 1

Comments to the Author

I have no more comments to the authors, and I agree that it could be published.

Reviewer: 2

Comments to the Author

Specific Comments:

Introduction

The background is too lengthy and not concise. Upon careful examination, it can be inferred that the main issue addressed in this research is the unappealing color of wet noodles, which is attempted to be addressed by adding blue-colored butterfly pea flower extract. The authors aim to investigate the impact of this extract on the quality, bioactive compound content, antioxidant activity, color, and sensory properties of wet noodles made from various composite flours. However, the direct impact of composite flour composition should not be the primary focus of this research, as it has already been reported in a previously published article (<https://www.mdpi.com/1420-3049/27/16/5062>).

Nevertheless, the authors have not provided a sufficiently strong rationale for using blue-colored butterfly pea flower extract. As commonly known, blue is not a common color for wet noodles or generally in food. Therefore, if the main issue to be addressed is the unappealing color of wet noodles, the authors need to include scientific reasons explaining why butterfly pea flower extract was chosen as the colorant.

Raw materials and preparation

- a. The specifications of the palm oil used need to be included.
- b. The author should provide an explanation or references for the extraction method (95°C for 3 minutes)
- c. Details about the treatment post-extraction, such as separating the extract from residual solids, need clarification.
- d. The author should analyze the total anthocyanins in the extract to assess whether there is significant damage to anthocyanins during the wet noodle production process. Anthocyanin damage during the wet noodle production process is highly likely, especially due to the application of relatively high heat (heating in boiled water for 2 minutes).
- e. The description of wet noodle production needs more detail to ensure reproducibility.
- f. Specify the amount of tapioca sprinkled on the wet noodle and the quantity of palm oil added to coat it.
- g. Several studies indicate that anthocyanins may undergo damage when exposed to temperatures of 60°C or higher for more than 30 minutes. Therefore, drying wet noodles at 60°C for 2 hours as preparation for extracting active compounds is highly likely to destroy some bioactive compounds. Freeze drying, undoubtedly, is a much better method.
- h. Explain the method of calculating total phenolic content to obtain it in units of mg GAE/kg dried noodles.
- i. Explain the method of calculating total flavonoid content to obtain it in units of mg CE/kg dried noodles.
- j. Anthocyanins in butterfly pea flower extracts are polyacylated anthocyanins, that show high color intensity at pH 4.5. Hence, anthocyanin analysis by pH differential method is not suitable. The single pH method is the appropriate analysis for the total anthocyanin analysis in butterfly pea flower extract.
- k. The author needs to provide an explanation or include a reference for the use of absorbance at 543 nm in calculating total anthocyanin.

l. The unit for total anthocyanin based on the formula is mg/ml. However, in the discussion, the author mentions the unit of anthocyanin as mg/kg dried noodles. The author needs to explain the method of how the conversion from mg/ml to mg/kg dried noodles is performed.

m. Authors need to explain how to determine antioxidant activity in units of mg GAE/kg dried noodles. The same should be done for the FRAP analysis.

n. A 15-point hedonic scale is an uncommon method. The author needs to provide a rationale for using a 15-point scale instead of the more commonly used 9 or 7-point scales. The author also needs to include an explanation regarding the statistical data analysis used for this sensory data.

o. The author needs to explain what the index effectiveness test is, considering that this test is rarely used in sensory evaluation

## Result and Discussion

- a. Authors should include a table showing the p-values for each studied factor for every observed/measured response. This would immediately reveal which factors significantly influence each response.
- b. The presentation of data in tables and graphs is still not effective and efficient. Most of the data is adequately represented in the tables, and most of the graphs are unnecessary.
- c. The discussion regarding the effect of composite flour proportions is repetitive from the discussion in <https://www.mdpi.com/1420-3049/27/16/5062>, thus diminishing the novelty value of this research.
- d. Moisture content analysis: Data has indicated that the moisture content of wet noodles is influenced by the composition of composite flour. The authors have outlined the roles of each component in composite flour (wheat flour, stinky lily flour, and κ-carrageenan) in water binding. However, the authors do not explain why moisture content tends to increase with a decrease in the ratio of stinky lily flour and an increase in the ratio of κ-carrageenan.
- e. Analyzing the color difference in wet noodles due to differences in butterfly pea flower extract concentrations is unnecessary. It is already evident that varying concentrations of butterfly pea flower extract as a color source will result in differences in color intensity. Authors should focus on analyzing whether there are significant color differences in treatments with the same concentration of butterfly pea flower extract but with different composite compositions. If there are significant differences, authors can provide insights into why these differences may occur.
- f. The highest proportion of κ-carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The authors explain that glucomannan in stinky lily powder has hydroxyl groups that can react with the Folin Ciocalteu reagent. Following this explanation, the consequence is that wet noodles with the highest proportion of stinky lily powder (or, in other words, the lowest proportion of κ-carrageenan) should have the highest TPC. However, the data indicates the opposite. How do the authors explain this?
- g. Table 7 was not found in the manuscript.
- h. Dominant anthocyanin pigment from butterfly pea extract is delphinidin [72] around 2.41 mg/g samples. □ This statement needs correction for two reasons. First, delphinidin is not an anthocyanin but an anthocyanidin. Second, all anthocyanins in butterfly pea flower extracts are derivatives of delphinidin, making the term 'dominant' less appropriate.
- i. Antioxidant Activity: This showed that the use of stinky lily flour and κ-carrageenan with a ratio of 17:3% (w/w) was able to reduce free hydroxyl groups which had the potential as electron or hydrogen donors in testing TPC, TFC and DPPH. Although the K2 treatment exhibits the highest antioxidant activity, the statement above is speculative because there is no direct evidence indicating that stinky lily flour and κ-carrageenan with a ratio of 17:3% (w/w) reduce free hydroxyl groups.
- j. If the main objective of this research is to produce wet noodles with a more attractive color, then sensory evaluation should be the most crucial part of the discussion. However, the discussion on the sensory properties of wet noodles has been inadequate.

Table 4. The use of superscript alphabets is confusing.

- a. How are they ranked? Are the 12 data in one column compared to each other? If so, it's confusing. Take Color, for example:

How do the authors explain  $8.69a = 10.73a$ ,  $8.69a < 8.96b$ , while  $10.73a <> 10.73c$ ? The same applies to other attributes (aroma, taste, texture).

Associate Editor: 2

Comments to the Author:

The manuscript need to be revised according to the comments of the reviewer.

Editor to the Author:

The article lacks two parts (Author contributions and Data availability) in structure. Please refer to "For Authors" or recent online articles, supplement to the "Author's contributions" column and "Data availability" column.

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1 **Effect of butterfly pea (*Clitoria ternatea*) flower extract **to-on** qualities, sensory properties,**  
2 **and antioxidant activity of wet noodles with various composite flour proportions**

3  
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7 Surabaya Catholic University, Dinoyo Street Number 42-44, Surabaya, Indonesia 60265

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11  
12 **Abstract**

13 The improvement of wet noodles' qualities, sensory, and functional properties was made  
14 by using the composite flour base added with the butterfly pea flower extract. The composite flour  
15 consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1  
16 (K1), 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentrations of butterfly pea  
17 extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block  
18 design with two factors, namely the composite flour and the concentration of butterfly pea flower  
19 extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30,  
20 K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and  
21 butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive  
22 compounds, and antioxidant activities of wet noodles. However, each factor also significantly  
23 influenced the physical properties of wet noodles, such as moisture content, water activity, tensile  
24 strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3 % (w/w) in the  
25 mixture increased moisture content, swelling index, and tensile strength but reduced water activity  
26 and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -  
27 carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic  
28 sensory score.

29 **Keywords:** composite flour, butterfly pea flower, quality, sensory, wet noodles

30

## 31 Introduction

32 The use of composite flour in wet noodles has been widely used to increase its functional  
33 value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et  
34 al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of  
35 wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w)  
36 could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made  
37 from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer  
38 acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of  
39 wet noodles and antioxidant activity.

40 A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
41 composited with wheat flour to increase the functional value of noodles by increasing biological  
42 activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending  
43 gastric emptying time.<sup>[5,6]</sup> however, this resulted in an unattractive wet noodle color. Therefore,  
44 it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their  
45 functional properties, one of which is the butterfly pea flower.

46 Composite flour is a mixture of several types of flour, usually composed of several types  
47 of carbohydrate sources (tubers, legumes, cereals) with or without wheat flour<sup>[1,2]</sup>. The composite  
48 flour is made to obtain suitable material characteristics for the desired processed product with  
49 certain functional properties<sup>[3]</sup>. The use of composite flour in wet noodles has been widely carried  
50 out to increase its functional values and several characteristics, including physical, chemical, and  
51 sensory properties. Siddeeg et al.<sup>[4]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to  
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54 claimed that noodles made from wheat flour blended with fenugreek flour for up to 7 % produced  
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57 A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
58 composited with wheat flour to increase the functional values of noodles by increasing the  
59 biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and  
60 prolonging gastric emptying time<sup>[8,9]</sup>. However, adding stink lily flour to base noodle flour resulted  
61 in wet noodles' limited elasticity and tensile strength<sup>[10,11]</sup>. Therefore, the  $\kappa$ -carrageenan was  
62 introduced to improve the texture properties of wet noodles. Those components collaborated with  
63 glucomannan to form cross-linking with glutenin and gliadin by inter- and intra-molecular bonds,  
64 improving noodle texture<sup>[12-14]</sup>. Widyawati et al.<sup>[15]</sup> explained that using the composite flour  
65 consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total  
66 phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl-free  
67 radical scavenging activity (DPPH), which influences the effectivity of bioactive compounds in  
68 the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients  
69 containing phenolic compounds can be added to increase composite flour's functional values as a  
70 source of antioxidants. Czajkowska-González et al.<sup>[16]</sup> mentioned that incorporating phenolic  
71 antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[15]</sup>  
72 added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles; however, this resulted  
73 in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to  
74 enhance the wet noodles' color profile and their functional properties, one of which is the butterfly  
75 pea flower.

76 Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with  
77 various flower colors, such as purple, blue, pink, and white<sup>[17]</sup>. This flower has phytochemical  
78 compounds that benefit as antioxidant sources<sup>[18,19]</sup>, including anthocyanins, tannins, phenolics,  
79 flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol  
80 glycosides<sup>[20,21]</sup>. Anthocyanins of the butterfly pea flower has been used as natural colorants in  
81 many food products<sup>[22,23]</sup>, one of them is wet noodle<sup>[24,25]</sup>. The phytochemical compounds,  
82 especially phenolic compounds, can influence the interaction among gluten, amylose, and  
83 amylopectin, depending on partition coefficients, keto groups, double bonds (in the side chains),  
84 and benzene rings<sup>[26]</sup>. This interaction involves their formed covalent and non-covalent bonds,  
85 which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility  
86<sup>[27]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as  
87 pluchea leaf<sup>[15,28]</sup>, gendarussa leaf (*Justicia gendarussa* Burm.F.)<sup>[29]</sup>, carrot and beetroot<sup>[30]</sup>,  
88 kelakai leaf<sup>[31]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory  
89 properties of wet noodles. Shiau et al.<sup>[25]</sup> utilized the natural color of butterfly pea flower extract  
90 to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH  
91 and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved  
92 the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility.  
93 Until now, the application of water extract of butterfly pea flowers in wet noodles has been  
94 commercially produced, but the interactions among phytochemical compounds and ingredients of  
95 wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been  
96 elucidated. Therefore, the current study aimed to determine the effect of composite flour and  
97 butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and  
98 sensory properties. Widyawati et al.<sup>[7]</sup> explained that using the composite flour consisting of wheat

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102 that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic  
103 compounds can be added to increase composite flour's functional values as a source of  
104 antioxidants. Czajkowska-González et al. [8] mentioned that incorporating phenolic antioxidants  
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106 extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an  
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110 Butterfly pea (*Clitoria ternatea*) is an herb plant from the Fabaceae family with various  
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121 leaf [7,20], gendarussa leaf (*Justicia gendarussa* Burm.F.) [21], carrot and beetroot [22], kelakai leaf [23]

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128 produced, but the interactions among phytochemical compounds and ingredients of wet noodles  
129 base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated.  
130 Therefore, the current study aimed to determine the effect of composite flour and butterfly pea  
131 flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory  
132 properties.

133

134

## 135 **Materials and Methods**

### 136 **Raw materials and preparation**

137 Butterfly pea flowers were obtained from Penjaringan Sari **gardenGarden**, Wonorejo,  
138 Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight,  
139 powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using  
140 a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group,  
141 China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95  
142 °C for 3 min **based on the modified method of Widyawati et al. <sup>[20]</sup> and Purwanto et al. <sup>[24]</sup>** to get  
143 three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-  
144 composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari



145 Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat,  
146 Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratios of  
147 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

#### 148 **Chemical and reagents**

149 Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate  
150 were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin–  
151 Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium  
152 hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide,  
153 chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA).  
154 Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

#### 155 **Wet noodles preparation**

156 Wet noodles were prepared based on the modified formula of Panjaitan et al. [254], as  
157 shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed  
158 with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were  
159 then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer  
160 OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about  
161 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to get  
162 noodles about 0.1 cm wide. The dough was sheeted and cut using rollers equipped with cutting  
163 blades (Oxone OX355AT, China). Raw wet noodle strains were sprinkled with tapioca flour (Rose  
164 Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before heated in boiled water (100 °C) with  
165 a ratio of raw noodles: water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil  
166 (Sania, PT Wilmar Nabati Indonesia) (5% w/w) before being subjected to quality and sensory

167 properties measurements, whereas uncooked noodles without oil coating were used to analyze  
168 bioactive compounds and antioxidant activity.

### 169 **Extraction of bioactive compounds of wet noodles**

170 Wet noodles were extracted based on the method of Widyawati et al.<sup>[745]</sup>. Raw noodles  
171 were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at  
172 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR  
173 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture  
174 (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and  
175 centrifuged at 5000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in  
176 an extraction time for three intervals. **The supernatant was collected and separated from the residue**  
177 **and then supernatant was** evaporated using a rotary evaporator (Buchi-rotary evaporator R-210,  
178 Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The  
179 obtained extract was used for further analysis.

### 180 **Moisture content analysis**

181 The water content of cooked wet noodles was analyzed using the thermogravimetric  
182 method <sup>[2632]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying  
183 oven at 105-110 °C for 1 h. The processes were followed by weighing the sample and measuring  
184 moisture content after obtaining a constant sample weight. The moisture content was calculated  
185 based on the difference of initial and obtained constant sample weight divided by the initial sample  
186 weight, expressed as a percentage of wet base.

### 187 **Water activity analysis**

188 The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity  
189 Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into  
190 an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity [2733].

### 191 **Tensile strength analysis**

192 Tensile strength is an essential parameter that measures the extensibility of cooked wet  
193 noodles [2839]. About 20 cm of the sample was measured for its tensile strength using a texture  
194 analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT  
195 Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and  
196 post-test speed at 1 mm/s, 3 mm, and 10 mm/s, respectively. Distance, time, and trigger force were  
197 set to 100 mm, 5 sec, and 5 g, respectively.

### 198 **Color analysis**

199 Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed  
200 using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al. [2935].  
201 The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), Hue ( $^{\circ}h$ ), and chroma  
202 ( $C$ ).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an  
203 interval between -80 - +100.  $b^*$  value represents a yellow color with an interval of -70 - +70 [306].  
204  $C$  indicates the color intensity and  $^{\circ}h$  states the color of samples [317].

### 205 **Swelling index analysis**

206 The swelling index was determined using a modified method by Islamiya et al. [328].  
207 Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL  
208 boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw  
209 wet noodles to absorb water that increased the weight of raw wet noodles [339]. The  
210 swelling index was measured from the difference in noodle weights before and after boiling.

### 211 **Cooking loss analysis**

212 The cooking loss of the raw wet noodles was analyzed using a modified method by Aditia  
213 ~~et al.~~ ~~et al.~~ [3440]. The cooking loss expresses the weight loss of wet noodles during cooking,  
214 indicated by the cooking water that ~~turn~~ ~~turns~~ ~~to~~ cloudy and thick [3541]. About 5 g of the raw wet  
215 noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then,  
216 the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was  
217 constant.

### 218 **Total phenolic content analysis**

219 The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's  
220 phenol reagent based on the modified method by Eyele ~~et al.~~ ~~et al.~~ [3642]. About 50 µL of the extract  
221 was added with 1 mL of 10 % Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask,  
222 homogenized, and incubated for 5 min. Then, 2 mL of 7.5 % Na<sub>2</sub>CO<sub>3</sub> was added, and the volume  
223 was adjusted to 10 mL with distilled water. The solution's absorbance was measured  
224 spectrophotometrically at λ 760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The  
225 standard reference used was gallic acid  $(y=0.0004x+0.0287, R^2=0.9877)$ , and the result was  
226 expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg  
227 GAE/kg dried noodles) was calculated using the equation = [(As-0.0287)/0.0004][2 mL/x  
228 g][1L/1000mL][1000g/1kg], where As=absorbance of the samples and x=weight of the dried  
229 noodles.

230

### 231 **Total flavonoid content analysis**

232 Total flavonoid content was analyzed using the modified method by Li ~~et al.~~ ~~et al.~~ [372043].  
233 The procedure began with mixing 0.3 mL of 5 % NaNO<sub>2</sub> and 250 µL of noodle extract in a 10 mL

234 volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10 % AlCl<sub>3</sub> was added  
 235 ~~into to~~ the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was  
 236 adjusted to 10 mL with distilled water. The sample was homogenized ~~prior to before~~ analysis using  
 237 a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ. 510 nm. The result  
 238 was determined using a (+)-catechin standard reference  $(y=0.0008x+0.0014, R^2=0.9999)$  and  
 239 expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg  
 240 dried noodles) was calculated using the equation = [(As-0.0014)/0.0008][2 mL/x  
 241 g][1L/1000mL][1000g/1kg], where As=absorbance of the samples and x=weight of the dried  
 242 noodles.

#### 244 Total anthocyanin content analysis

245 Total anthocyanin content was determined using the method of ~~Giusti Giusti~~ and Wrolstad  
 246 <sup>[3844]</sup>. About 250 μL of the sample was added with buffer solutions at pH 1 and pH 4.5 in different  
 247 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at λ 543  
 248 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples  
 249 was calculated with the formula:  $A = (A_{543} - A_{700})_{pH 1.0} - (A_{543} - A_{700})_{pH 4.5}$ .

250 The total anthocyanin monomer content (TA) (mg/mL) was calculated with the formula:  
 251  $\frac{AxMWxDFx1000}{\epsilon x l}$ , where A was the absorbance of samples, MW was the molecular weight of  
 252 delphinidin-3-glucoside (449.2 g/mol), DF was the factor of sample dilution, and ε was the  
 253 absorptivity molar of delphinidin-3-glucoside (29000 L cm<sup>-1</sup> mol<sup>-1</sup>). TA monomer (mg  
 254 delphinidine-3-glucoside/kg dried noodles) was calculated using the equation= [TA (mg/L)]  
 255 [2mL/x g][1L/1000mL][1000g/1kg], where x=the weight of dried noodles.

256

257

258

## 259 **2,2-Diphenyl-1-picrylhydrazyl-free picrylhydrazyl free radical scavenging activity**

260 DPPH analysis was measured based on the methods of Shirazi *et al.* [3945] and

261 Widyawati *et al.* [406]. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing

262 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark

263 room. The solution was centrifuged at 5000 rpm for 5 min, and the absorbance of samples was

264 measured at  $\lambda$  517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant

265 activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference

266 ( $y=0.1405x+2.4741$ ,  $R^2=0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of

267 dried noodles. **The percentage of DPPH free radical scavenging activity was calculated using the**

268 **equation:**

269 **Inhibition of DPPH free radical scavenging activity (y) (%) = [(A0-As)/A0]x 100%, where A0=**

270 **absorbance of the control and As=absorbance of the samples. DPPH free radical scavenging**

271 **activity (mg GAE/kg dried noodles) = [ (y-2.4741)/0.1405] [2mL/x g][1L/1000mL][1000g/1kg].**

272 **where x=the weight of dried noodles.**

273

## 274 **Ferric reducing antioxidant power**

275 FRAP analysis was performed using the modified method of Al-Temimi and Choundhary

276 [417]. Approximately 50  $\mu$ L of the extract in a test tube was added with 2.5 mL of phosphate buffer

277 solution at pH 6.6 and 2.5 mL of 1 % potassium ferric cyanide, shaken and incubated for 20 min

278 at 50 °C. After incubation, the solution was added with 2.5 ml of 10 % mono-chloroacetic acid and

279 shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of

280 bi-distilled water and 2.5 mL of 0.1 % ferric chloride and incubated for 10 min. After incubation,  
281 samples were measured with absorbance at  $\lambda$  700 nm (Spectrophotometer UV-Vis 1800,  
282 Shimadzu, Japan). Gallic acid was used as the standard reference ( $y=2.2025x-0.0144$ ,  $R^2=0.9983$ ),  
283 and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. **The**  
284 **reducing power of samples was calculated using the formula:**

$$285 \quad \text{The reducing power (RP) (\%)} = [(A_s - A_0) / A_s] \times 100\%$$

286 **Where  $A_0$ = absorbance of the control and  $A_s$ =absorbance of the samples. FRAP (mg GAE/kg**  
287 **dried noodles) = [ (RP+0.0144)/2.2025] [2mL/x g][1L/1000mL][1000g/1kg], where x=the weight**  
288 **of dried noodles.**

## 291 **Sensory evaluation**

292 **The sensory properties of cooked wet noodles were analyzed based on Nugroho et al.<sup>[428]</sup>**  
293 **with modifications. The assessment used hedonic scale scoring with the parameters including**  
294 **color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very dislike, and 15**  
295 **was very like. This sensory analysis was performed by 100 untrained panelists between 17 and 25**  
296 **years old who had previously gained knowledge of the measurement procedure. Each panelist was**  
297 **presented with twelve (12) samples to be tested and given a questionnaire containing testing**  
298 **instructions and asked to give a score to each sample according to their level of liking. The hedonic**  
299 **scale used is a value of 1-15 given by panelists according to their level of liking for the product. A**  
300 **score of 1-3 indicates very dislike, a score of 4-6 does not like, a score of 7-9 is neutral, a score of**  
301 **10-12 likes it, and a score of 13-15 is very like it.** The best treatment was determined by the index  
302 **effectiveness test <sup>[431]</sup>. The best determination was based on sensory assay which included**

303 preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of  
304 0-1 on each parameter based on the level of importance of each parameter. The higher the weight  
305 value given means the parameter was increasingly prioritized. The treatment that has the highest  
306 value was determined as the best treatment. Procedure to determining of the best treatment for wet  
307 noodles included:

308 a. Calculation of the average of the weight parameters based on the results filled in by panelists

309 b. Calculation of normal weight (BN)

310  $BN = \text{Variable weight} / \text{Total weight}$

311 c. Calculation of effectiveness value (NE)

312  $NE = \text{Treatment value} - \text{worst value} / \text{Best value} - \text{worst value}$

313 d. Calculation of yield value (NH)

314  $NH = NE \times \text{normal weight}$

315 d. Calculation of the total productivity value of all parameters

316  $\text{Total NH} = \text{NH of color} + \text{NH of texture} + \text{NH of taste} + \text{NH of aroma}$

317 e. Determining the best treatment by choosing the appropriate treatment had the largest total NH

318

### 319 **Design of experiment and statistical analysis**

320 The design of experiment used was a randomized block design (RBD) with two factors,  
321 i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan)  
322 including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-  
323 butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment  
324 was performed in three replications. The homogenous triplicate data were expressed as the mean  
325  $\pm$  SD. The one-way analysis of variance (ANOVA) was done, and Duncan's New multiple range



326 test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical  
327 analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## 328 **Results and discussions**

### 329 **Quality of Wet Noodles**

330 The quality results of the wet noodles, including moisture content, water activity, tensile  
331 strength, swelling index, cooking loss, and color, are shown in [Table 2, 3, 4, dan 5](#), and [Fig.1, 2,](#)  
332 [3, and 4](#). Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly  
333 influenced by the various ratios of composite flour ( $p \leq 0.05$ ) ([Table 3](#) [Fig. 4](#)). However, the  
334 interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea  
335 extract, or the concentrations of butterfly pea extract itself did not give any significant effects on  
336 the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water  
337 content (70 % wet base) compared to K0 (68 % wet base), K1 (68 % wet base), and K2 (69 % wet  
338 base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan  
339 proportion influenced the amount of free and bound water in the wet noodle samples, which also  
340 increased the water content of the wet noodles. Water content resembles the amount of free and  
341 weakly bound water in the samples' pores, intermolecular, and intercellular space [\[745,208\]](#). Protein  
342 networking between gliadin and glutelin forms a three-dimensional networking structure of gluten  
343 involving water molecules [\[449\]](#). The glucomannan of stinky lily flour can form a secondary  
344 structure with sulfhydryl groups of gluten network to stabilize the gluten network, increasing water  
345 binding capacity and retarding the migration of water molecules [\[4550\]](#).  $\lambda$ -carrageenan can bind  
346 water molecules around 25-40 times [\[4654\]](#). The  $\kappa$ -carrageenan can cause a structure change [of in](#)  
347 gluten protein through electrostatic interactions and hydrogen bonding [\[4752\]](#). The interaction  
348 among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour,

349 and  $\lambda$ -carrageenan also changed the conformation of the three-dimensional network structure  
350 formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular disulfide  
351 bonds that can establish water mobility in the dough of the wet noodles. The interaction of all  
352 components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ )  
353 (Table 3 Fig. 4). The addition of  $\kappa$ -carrageenan between 1-3 % in the wet noodle formulation  
354 reduced the  $A_w$  by about 0.005-0.006. The capability of  $\lambda$ -carrageenan to absorb water molecules  
355 reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and  
356 ester sulfate groups of them to form complex structures [4853]. The complexity of the reaction  
357 among components in the wet noodles to form a three-dimensional network influenced the amount  
358 of free water molecules that determined water activity values. The strength of the bonding among  
359 the components between wet noodles and water molecules also contributed to the value of the  
360 water activity.

361 Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly  
362 influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea  
363 flower extract ( $p \leq 0.05$ ) (Table 3 Fig. 4 and 42). However, the interaction between the two factors  
364 was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq$   
365 0.05) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the  
366 tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other  
367 hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased  
368 the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected  
369 the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating  
370 butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) to significantly  
371 decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index

372 values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles  
373 ranged from 128 to 159 %. The effect of the composite flour proportion of wet noodles showed  
374 that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking  
375 loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest  
376 cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The  
377 cooking loss values of wet noodles ranged from 18 to 19 %.

378 Tensile strength, cooking loss, and swelling index of wet noodles were significantly  
379 influenced by the interaction of components in dough formation, namely gluten, gliadin,  
380 glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional  
381 network structure that determined the capability of the noodle strands being resistance to break  
382 and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed  
383 of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  
384  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[4954]</sup> that can bind water molecule to form a gel.  
385 Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose  
386 that can absorb water molecules around 200 times<sup>[5055]</sup> to form a strong gel that increases the  
387 viscosity and swelling index of the dough<sup>[5161]</sup>. Park and Baik<sup>[5271]</sup> stated that the gluten network  
388 formation affects the tensile strength of noodles. Huang et al.<sup>[4853]</sup> also reported that  $\kappa$ -carrageenan  
389 can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-  
390 binding capacity. Cui et al.<sup>[4559]</sup> claimed that konjac glucomannan not only stabilizes the structure  
391 of gluten network but also reacts with free water molecules to form a more stable three-  
392 dimensional networking structure, thus maintaining dough's rheological and tensile properties.

393 The increased swelling index of dough is caused by the capability of glucomannan to  
394 reduce the pore size and increase the pore numbers with uniform size<sup>[538]</sup>. The synergistic

395 interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and  
396 stable gel because of the association and lining up of the mannan molecules into the junction zones  
397 of helices [549]. The cross-linking and polymerization involving functional groups of gluten protein,  
398  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger  
399 attraction between molecules composed of cross-linking reduces the particles or molecules' loss  
400 during cooking [549,5560]. The stability of the network dimensional structure of the protein was  
401 influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol  
402 compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking  
403 loss of wet noodles. Schefer et al. [1927] and Widyawati et al. [715] explained that phenolic compounds  
404 can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and  
405 carbohydrate (amylose) to form a complex structure through many interactions, including  
406 hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking.  
407 The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan,  
408 protein, or polysaccharide and influenced complex network structure. The phenolic compounds  
409 can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan,  
410 and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds,  
411 and disruption of disulfide bridges to form thiols radicals [5560]. These compounds can form  
412 complexes with protein and hydrocolloids, leading to structural and functional changes and  
413 influencing gel formation through aggregation formation and disulfide bridge breakdown  
414 [1926,207,5664].

415 The color of wet noodles (Table 5 Fig. 3 and Fig. 14) was significantly influenced by the  
416 interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  
417  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract.

418 Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0,  
419 K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount  
420 of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about  
421 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness  
422 of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing  
423 butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -  
424 carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the  
425 strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -carrageenan  
426 in composite flour also supported the water-holding capacity of wet noodles that influenced color.  
427  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved  
428 sulfhydryl groups. Masakuni and Konishi<sup>[5762]</sup> reported that  $\kappa$ -carrageenan can associate polymer  
429 structure that involves intra- and intermolecular interaction, such as ionic bonding and  
430 electrostatic forces. The mechanism of making a three-dimensional network structure that  
431 implicated all components of composite flour was exceptionally complicated due to the involved  
432 polar and non-polar functional groups and many kinds of interaction between them. These  
433 influenced the water content and water activity of the wet noodles, which impacted the wet noodle  
434 color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from  
435 the butterfly pea extract. Gamage et al.<sup>[5863]</sup> reported that the anthocyanin pigment of butterfly pea  
436 is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration  
437 lowered the lightness, redness, yellowness, and chroma and also changed the hue color from  
438 yellow to green-blue color.

439 The effect of composite flour and butterfly pea extract on color was observed in chroma  
440 and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness,

441 but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[5964]</sup> also found similarities in  
442 their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky  
443 lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was  
444 yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow  
445 values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of  
446 butterfly pea extract. However, the higher concentration of butterfly pea extract lessened the green  
447 and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle  
448 color is also estimated to be influenced by the phenolic compound content, which underwent  
449 polymerization or degradation during the heating process. Widyawati et al.<sup>[208]</sup> reported that the  
450 bioactive compounds in pluchea extract could change the wet noodle color because of the  
451 discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue  
452 color due to different interactions between anthocyanin and hydrocolloid compounds, especially  
453  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

454

455

#### 456 **The phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) contents of wet** 457 **noodles**

458 The results of TPC, TFC, and TAC are shown in **Table 6Fig.-5**. The TPC and TFC of wet  
459 noodles were significantly influenced by the interaction between two parameters: the ratio of  
460 composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion  
461 of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had  
462 the highest TPC and TFC of about ~ 207 mg GAE/kg dried noodles and ~57 mg CE/kg dried  
463 noodles, respectively. The TAC of wet noodles was only influenced by the concentration of

464 butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract  
465 addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles.  
466 In addition, based on Pearson correlation assessment, there was a strong, positive correlation  
467 between the TPC of wet noodles and the TFC at T0 ( $r=0.955$ ), T15 ( $r=0.946$ ), and T30 treatments  
468 ( $r=0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and  
469 the TAC at T0 ( $r=0.153$ ) and T30 treatments ( $r=0.067$ ), except the T15 treatment, which had a  
470 correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were  
471 correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin  
472 pigment from butterfly pea extract is delphinidin [6065], around  $2.41$  mg/g samples [616] that has free  
473 more acyl groups and aglycone structure [627] that can be used as a natural pigment. The addition  
474 of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant  
475 agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated  
476 protein kinase pathway, and inflammatory cytokines signaling [638]. Nevertheless, butterfly pea  
477 extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils,  
478 triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and  
479 sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6<sup>''</sup>-  
480 malonylstragalol, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)  
481 [1220,1324], chlorogenic, gallic, p-coumaric, caffeic, ferulic, protocatechuic, p-hydroxy benzoic,  
482 vanillic, and syringic acids [627], ternatin anthocyanins, fatty acids, tocopherols, myo-inositol, pentanal,  
483 cyclohexene, 1-methyl-4-(1-methylethylidene), and hirsutene [649], that contribute to the  
484 antioxidant activity [108,649]. *Clitoria ternatea* shows to exhibit antioxidant activity based on the  
485 antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging,  
486 ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA),

487 hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical  
488 scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-  
489 sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays [649]. The TPC and  
490 TFC of wet noodles increased along with the higher proportion of glucomannan in the composite  
491 flour and the higher concentration of butterfly pea extract. Zhou et al. [6570] claimed that  
492 glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's  
493 phenol reagent. Devaraj et al. [6674] reported that 3,5-acetylalbulin is a flavonoid compound in  
494 glucomannan that can form a complex with  $\text{AlCl}_3$ .

#### 495 **Antioxidant activity of wet noodles**

496 The antioxidant activity (AOA) of wet noodles was determined using DPPH radical  
497 scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table  
498 6Fig-5. The proportion of composite flour and the concentration of butterfly pea extracts  
499 significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging  
500 from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour  
501 of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while  
502 the samples containing composite flour K2 with butterfly pea extracts 30 % (K2T30) had the  
503 highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively  
504 correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA  
505 at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values  
506 between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753,  
507 respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and  
508 T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan,  
509 phenolic compounds, amylose, gliadin, and glutelin in the dough of wet noodles determined the



510 number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati  
511 et al.<sup>[406]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds  
512 depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures.  
513 The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour  
514 and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18 and 2 % (w/w) of stinky lily  
515 flour and  $\kappa$ -carrageenan and 15 % (w/w) of extract. However, the use of 17 and 3 % (w/w) of  
516 stinky lily flour and  $\kappa$ -carrageenan and 30 % (w/w) of the extract showed a significant decrease.  
517 The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17:3 % (w/w)  
518 was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors  
519 in testing TPC, TFC, and DPPH.

520 FRAP of wet noodles was significantly influenced by the interaction of two parameters of  
521 the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP  
522 was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions.  
523 The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg  
524 GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had  
525 the lowest FRAP, while the samples containing composite flour K2 with 30 % of butterfly pea  
526 extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC  
527 at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment  
528 possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC  
529 at T0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15  
530 and T30 treatments showed weak negative correlations (Table 73). The obtained correlation  
531 between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with  
532 the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table

73). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radical radicals was higher than them to reduce ferric ion. It proved that the bioactive compounds of wet noodles ~~are~~ have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[6772]</sup>. Poli et al.<sup>[6873]</sup> stated that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[6974]</sup> claimed that a secondary antioxidant is a natural antioxidant that ~~has capability to~~ can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[7075]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[716]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[716]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymerization or complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[727]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of ~~electron~~ electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to

556 donating electrons. Paddayappa et al.<sup>[6772]</sup> reported that the phenolic compounds are capable of  
557 embroiling redox activities with an action as hydrogen donor and reducing agent. The weak  
558 relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there  
559 was an interaction between the functional groups in the benzene ring in phenolic and flavonoid  
560 compounds and the functional groups in components in composite flour, thereby reducing the  
561 ability of phenolic and flavonoid compounds to donate electrons.

## 562 **Sensory Evaluation**

563         Sensory properties of wet noodles based on the hedonic test results showed that composite  
564 flour and butterfly pea extract additions significantly influenced color, aroma, taste, and texture  
565 preferences ( $p \leq 0.05$ ) (Table 84). The preference values of color, aroma, taste, and texture  
566 attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating  
567 butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of  
568 wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color  
569 that resulted in color degradation from yellow, green, to blue color, impacting the color preference  
570 of wet noodles. Nugroho et al.<sup>[428]</sup> also informed that the addition of butterfly pea extracts elevated  
571 the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two  
572 parameters of treatments, where the results showed that the higher proportion of stinky lily caused  
573 the wet noodles to have a stronger, musty smell. Utami et al.<sup>[738]</sup> claimed that oxalic acid contained  
574 in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -  
575 carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists'  
576 preference for wet noodle aroma. Sumartini and Putri<sup>[749]</sup> noted that panelists preferred noodles  
577 substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[745]</sup> also proved that  $\kappa$ -carrageenan is an  
578 odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[638]</sup> added that volatile

579 compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal  
580 and mome inositol. In addition, Padmawati et al.<sup>[7589]</sup> revealed that butterfly pea extract could give  
581 a sweet and sharp aroma. The panelists' taste preference ~~to~~ for wet noodles without butterfly pea  
582 extract addition was caused by alkaloid compounds, i.e., conisin<sup>[7684]</sup> due to Maillard reaction  
583 during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher  
584 concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds  
585 in this flower, as has been found by Handayani and Kumalasari<sup>[7782]</sup>. The effect of composite  
586 flour proportion and butterfly pea extract addition also appeared to the texture preference of wet  
587 noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample,  
588 as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the  
589 tensile strength of wet noodles because of the different concentrations of butterfly pea extract  
590 added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted  
591 in sticky, easy-to-break, and less chewy wet noodles<sup>[1826,1927,7782]</sup> due to the competition among  
592 phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with  
593 water molecules to form gel<sup>[7883]</sup>. Based on the index effectiveness test, the noodles made with  
594 composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a  
595 total score of 1.0504.

## 596 **Conclusions**

597 Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and  
598 butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive compounds,  
599 antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose,  
600 glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network  
601 structure that impacted moisture content, water activity, tensile strength, color, cooking loss,

602 swelling index, bioactive content, antioxidant activity, and sensory properties of wet noodles. The  
603 higher concentration of hydrocolloid addition caused increased water content and swelling index  
604 and decreased water activity and cooking loss. In addition, incorporating butterfly pea extracts  
605 improved color, bioactive content, and antioxidant activity and enhanced panelist preference for  
606 wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract  
607 increased the functional value of resulting wet noodles.

608

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612

### 613 **Conflict of Interest**

614 The authors declare no conflict of interest

615

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906 Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

907 Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (% w/w). K1 = wheat flour: stink  
 908 lily flour:  $\kappa$ -carrageenan = 80:19:1 (% w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan =  
 909 80:18:2 (% w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (% w/w). T0 =  
 910 concentration of the butterfly pea extract = 0%. T15= concentration of the butterfly pea extract =  
 911 15 %. T30 = concentration of the butterfly pea extract = 30 -%.

Table 2. Quality properties of wet noodles at the various ratios of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

**NoteB:** No significant effect of interaction between composite flour and butterfly pea extract ~~to~~ on quality properties of wet noodles. The results were presented as SD of means that were achieved ~~by~~ in triplicate. All of ~~the~~ data showed that no interaction of ~~the~~ two parameters influenced ~~the~~ quality properties of wet noodles at  $p \leq 0.05$ .

Table 3. Effect of composite flour proportions on quality properties of wet noodles

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0	68.04±0.40 <sup>a</sup>	0.976±0.01 <sup>b</sup>	128.36±3.30 <sup>a</sup>	19.23±0.55 <sup>d</sup>	0.097±0.097 <sup>a</sup>
K1	68.20±0.74 <sup>a</sup>	0.971±0.01 <sup>a</sup>	133.58±8.42 <sup>b</sup>	18.93±0.34 <sup>c</sup>	0.112±0.111 <sup>b</sup>
K2	68.89±0.73 <sup>b</sup>	0.970±0.01 <sup>a</sup>	137.62±6.05 <sup>b</sup>	18.48±0.23 <sup>b</sup>	0.141±0.139 <sup>c</sup>
K3	69.52±0.73 <sup>c</sup>	0.971±0.01 <sup>a</sup>	159.11±6.77 <sup>c</sup>	17.96±0.40 <sup>a</sup>	0.173±0.171 <sup>d</sup>

Note: All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

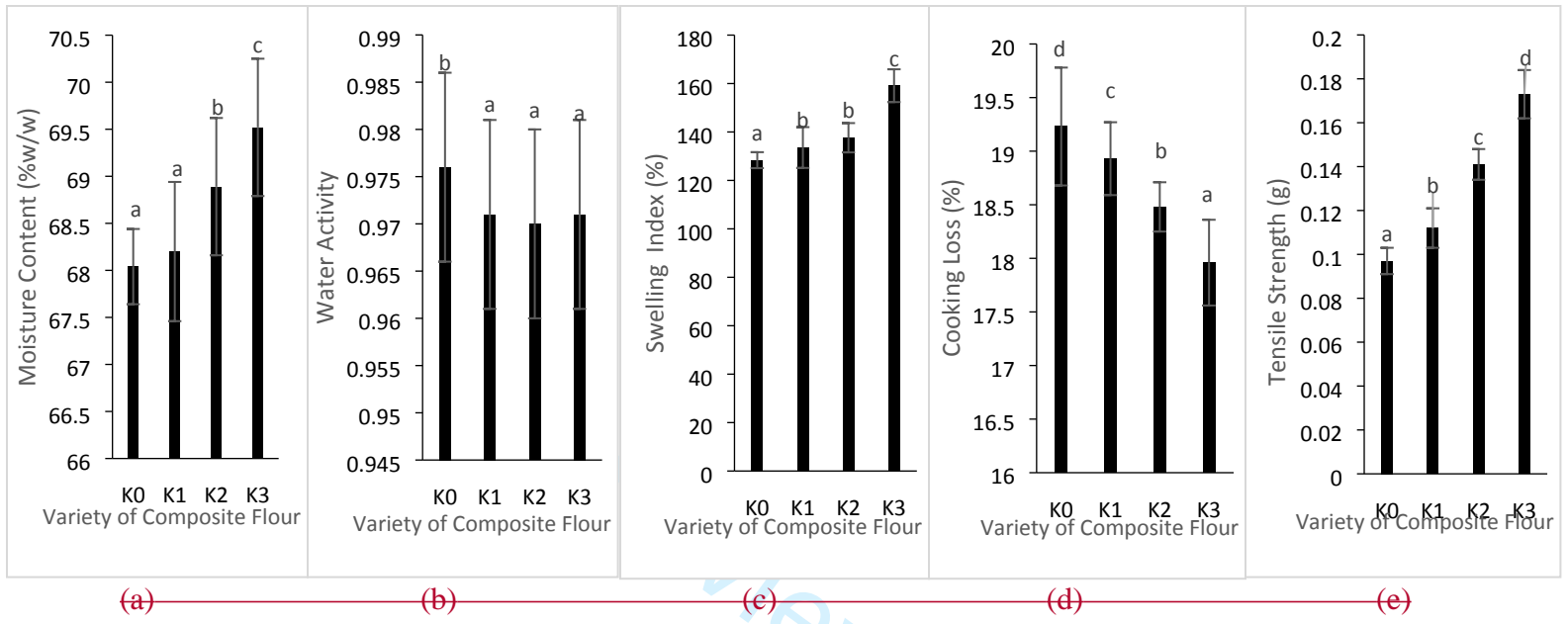
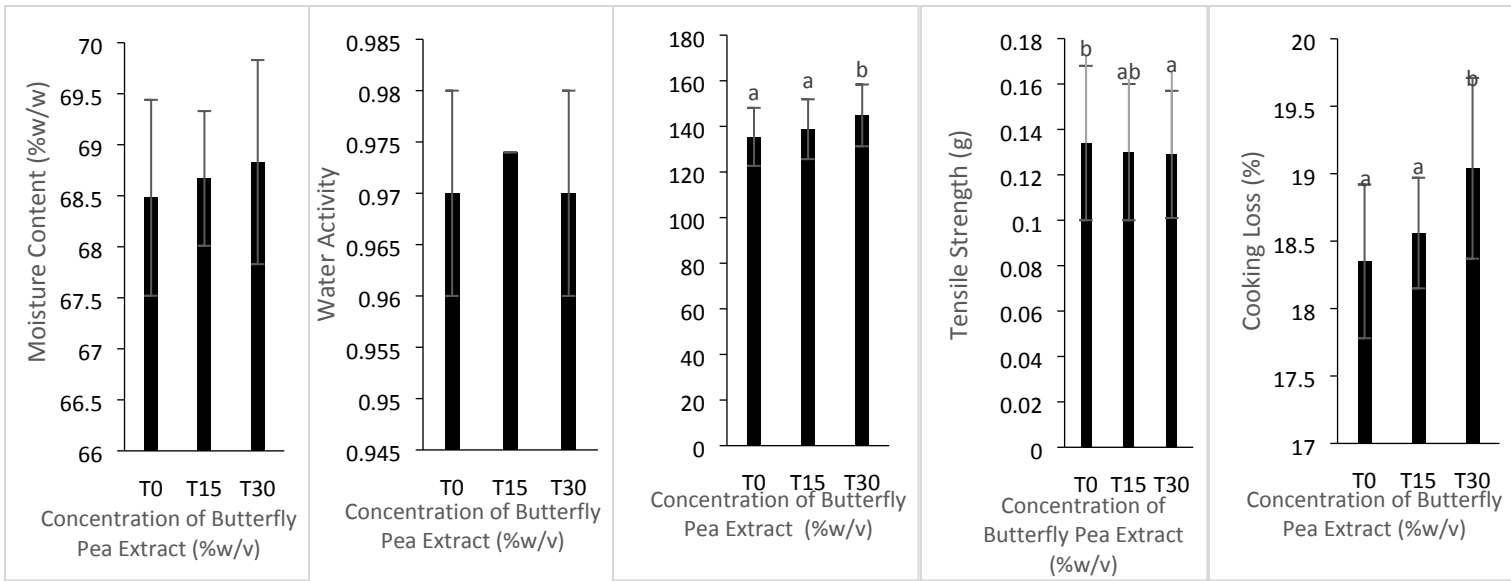


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

Table 4. Effect of butterfly pea extract concentration on quality properties of wet noodles

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
T0	68.48±0.96	0.970±0.010	135.41±12.72 <sup>a</sup>	18.35±0.57 <sup>a</sup>	0.134±0.034 <sup>b</sup>
T15	68.67±0.66	0.974±0.000	138.77±13.12 <sup>a</sup>	18.56±0.41 <sup>a</sup>	0.130±0.030 <sup>ab</sup>
T30	68.83±1.00	0.970±0.010	144.82±13.55 <sup>b</sup>	19.04±0.67 <sup>b</sup>	0.129±0.028 <sup>a</sup>

Note: All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .



(a) ————— (b) ————— (c) ————— (d) ————— (e)

Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .



Table 5. Effect of interaction between composite flour and butterfly pea extract on wet noodle's color

Samples	$L^*$	$a^*$	$b^*$	$C$	$h$
K0T0	66.10±0.30 <sup>f</sup>	0.90±0.10 <sup>f</sup>	15.70±0.10 <sup>f</sup>	15.70±0.10 <sup>f</sup>	86.60±0.20 <sup>a</sup>
K0T15	48.70±0.20 <sup>c</sup>	-11.40±0.30 <sup>bc</sup>	-3.50±0.20 <sup>c</sup>	12.00±0.30 <sup>c</sup>	197.00±0.70 <sup>c</sup>
K0T30	44.00±0.60 <sup>a</sup>	-12.80±0.20 <sup>a</sup>	-6.50±0.30 <sup>a</sup>	14.40±0.20 <sup>e</sup>	206.90±1.00 <sup>d</sup>
K1T0	67.10±0.40 <sup>f</sup>	0.90±0.20 <sup>f</sup>	15.80±0.60 <sup>f</sup>	15.80±0.60 <sup>f</sup>	86.60±0.50 <sup>a</sup>
K1T15	51.50±1.80 <sup>d</sup>	-10.80±0.40 <sup>cd</sup>	-3.00±0.20 <sup>cd</sup>	11.30±0.40 <sup>bc</sup>	195.60±0.60 <sup>c</sup>
K1T30	45.50±0.20 <sup>b</sup>	-11.80±0.80 <sup>b</sup>	-6.30±0.30 <sup>a</sup>	13.40±0.70 <sup>d</sup>	208.40±2.30 <sup>d</sup>
K2T0	67.10±0.20 <sup>f</sup>	1.00±0.10 <sup>f</sup>	16.30±0.10 <sup>fg</sup>	16.30±0.10 <sup>fg</sup>	86.40±0.10 <sup>a</sup>
K2T15	53.40±0.30 <sup>e</sup>	-10.30±0.80 <sup>de</sup>	-2.80±0.10 <sup>d</sup>	10.70±0.80 <sup>b</sup>	195.50±1.30 <sup>c</sup>
K2T30	46.00±0.40 <sup>b</sup>	-10.40±0.20 <sup>de</sup>	-6.10±0.40 <sup>a</sup>	12.10±0.40 <sup>c</sup>	210.60±1.30 <sup>e</sup>
K3T0	67.40±0.30 <sup>f</sup>	1.20±0.10 <sup>f</sup>	16.80±0.70 <sup>g</sup>	16.90±0.70 <sup>g</sup>	85.90±0.20 <sup>a</sup>
K3T15	53.80±1.30 <sup>e</sup>	-9.80±0.70 <sup>e</sup>	-1.20±0.20 <sup>e</sup>	9.90±0.70 <sup>a</sup>	187.50±1.10 <sup>b</sup>
K3T30	47.90±0.70 <sup>c</sup>	-10.10±0.40 <sup>de</sup>	-5.50±0.30 <sup>b</sup>	11.60±0.20 <sup>bc</sup>	208.40±2.30 <sup>d</sup>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

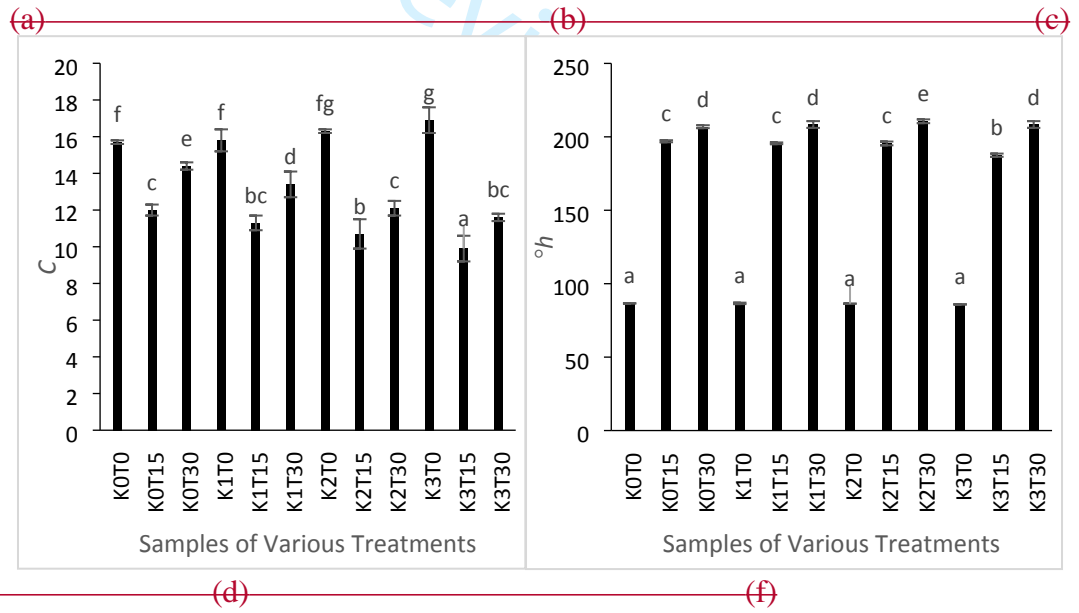
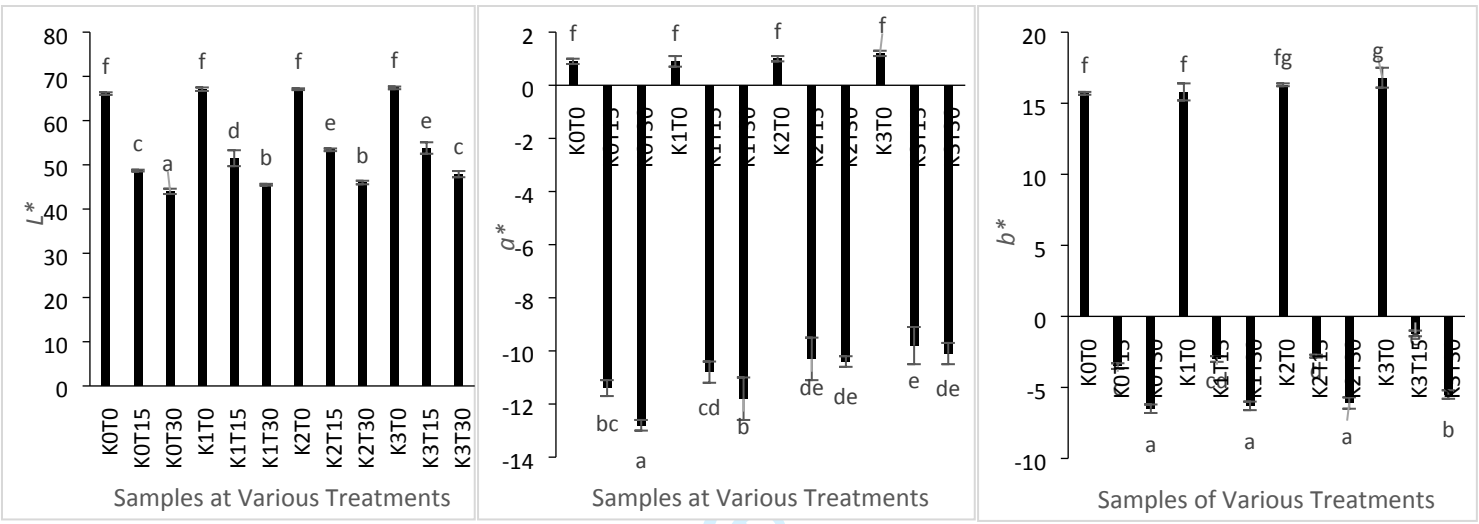


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L\**, b. *Redness/a\**, c. *Yellowness/b\**, d. *Chroma/C*, e. *Hue/h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

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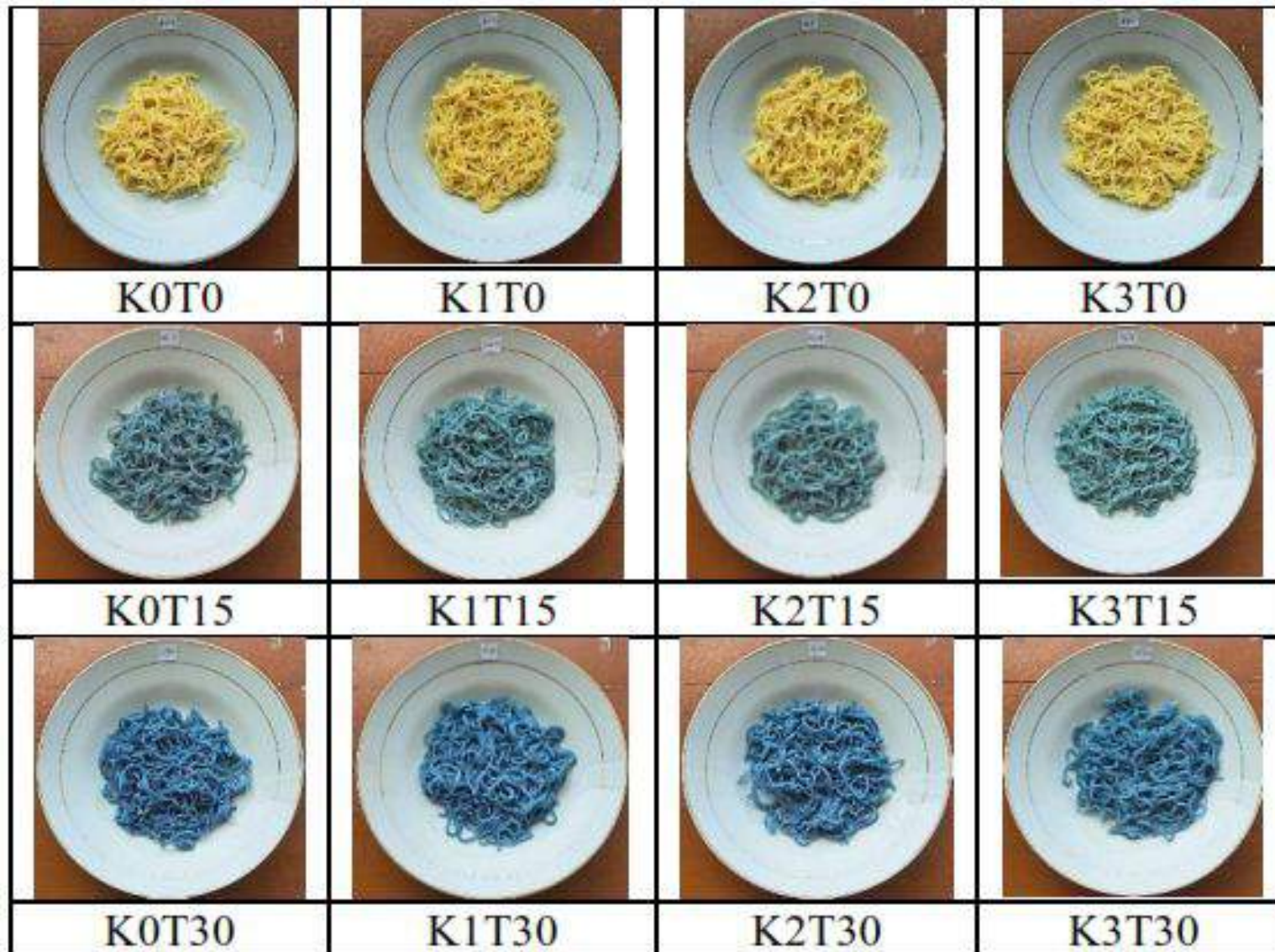
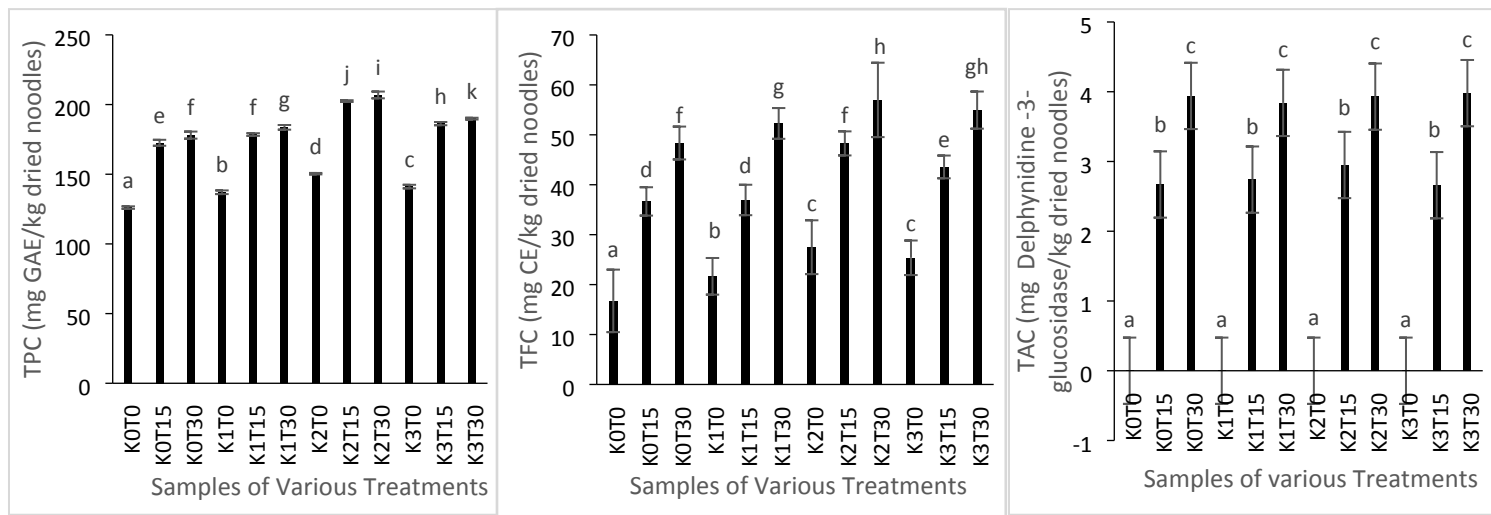


Figure 14. Color of wet noodles at various ~~proportion-proportions~~ of composite flour and ~~concentration-concentrations~~ of butterfly pea flower extract

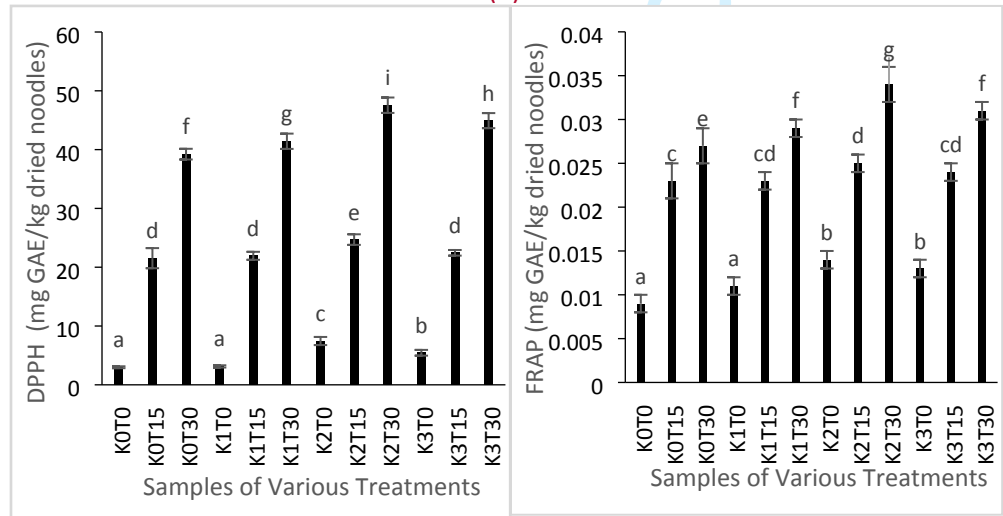
Table 6. Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07±0.90 <sup>a</sup>	16.74±6.26 <sup>a</sup>	0.00±0.00 <sup>a</sup>	2.99±0.16 <sup>a</sup>	0.009±0.001 <sup>a</sup>
K0T15	172.57±2.14 <sup>e</sup>	36.66±2.84 <sup>d</sup>	2.67±0.21 <sup>b</sup>	21.54±1.71 <sup>d</sup>	0.023±0.002 <sup>c</sup>
K0T30	178.07±2.54 <sup>f</sup>	48.36±3.29 <sup>f</sup>	3.94±0.28 <sup>c</sup>	39.23±0.91 <sup>f</sup>	0.027±0.002 <sup>c</sup>
K1T0	137.07±1.32 <sup>b</sup>	21.66±3.67 <sup>b</sup>	0.00±0.00 <sup>a</sup>	3.13±0.19 <sup>a</sup>	0.011±0.001 <sup>a</sup>
K1T15	178.48±0.95 <sup>f</sup>	36.95±3.05 <sup>d</sup>	2.74±0.21 <sup>b</sup>	21.94±0.68 <sup>d</sup>	0.023±0.001 <sup>cd</sup>
K1T30	183.65±1.67 <sup>g</sup>	52.28±3.08 <sup>g</sup>	3.84±0.19 <sup>c</sup>	41.42±1.30 <sup>g</sup>	0.029±0.001 <sup>f</sup>
K2T0	150.40±0.52 <sup>d</sup>	27.49±5.39 <sup>c</sup>	0.00±0.00 <sup>a</sup>	7.45± 0.69 <sup>c</sup>	0.014±0.001 <sup>b</sup>
K2T15	202.48±0.63 <sup>j</sup>	48.28±2.41 <sup>f</sup>	2.95±0.57 <sup>b</sup>	24.70±0.90 <sup>e</sup>	0.025±0.001 <sup>d</sup>
K2T30	206.90±2.43 <sup>i</sup>	56.99±7.45 <sup>h</sup>	3.93±0.42 <sup>c</sup>	47.55±1.31 <sup>i</sup>	0.034±0.002 <sup>g</sup>
K3T0	141.15±1.28 <sup>c</sup>	25.37±3.46 <sup>c</sup>	0.00±0.00 <sup>a</sup>	5.45±0.49 <sup>b</sup>	0.013±0.001 <sup>b</sup>
K3T15	186.32±1.15 <sup>h</sup>	43.57±2.28 <sup>e</sup>	2.66±0.21 <sup>b</sup>	22.45±0.48 <sup>d</sup>	0.024±0.001 <sup>cd</sup>
K3T30	189.90±0.63 <sup>k</sup>	54.95±3.72 <sup>gh</sup>	3.98±0.37 <sup>c</sup>	44.93±1.28 <sup>h</sup>	0.031±0.001 <sup>f</sup>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .



(a) (b) (c)



—(d)—————(e)

Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different,  $p \leq 0.05$ .

Table 73. Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)

Table 84. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

NB: The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .



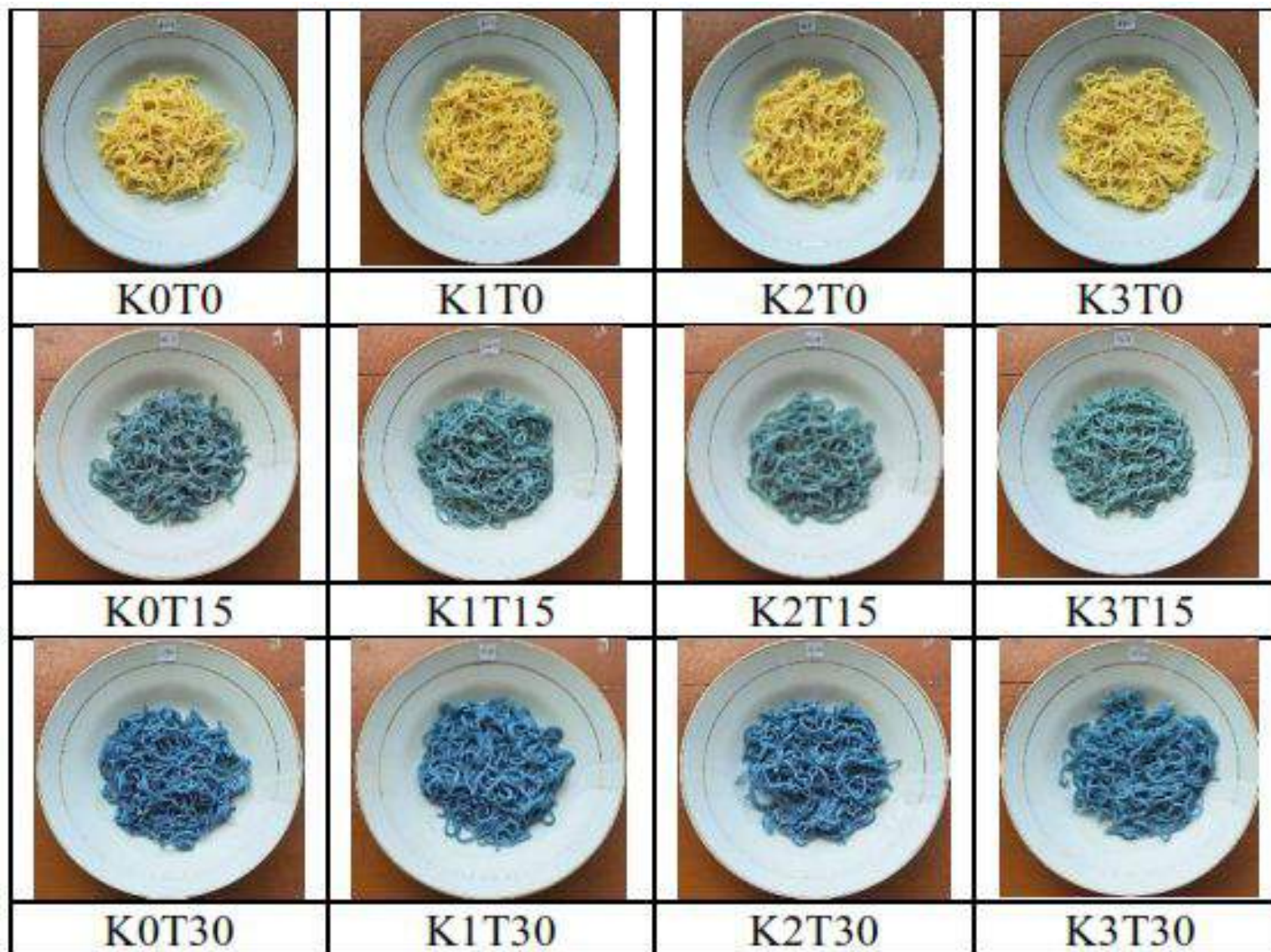


Figure 1. Color of wet noodles at various proportions of composite flour and concentrations of butterfly pea flower extract

Table 1. Formula of wet noodles

Treatment	Code	Ingredients					Composite flour (g)
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)		
1	K0T0	3	30	30	0	150	
2	K0T15	3	30	0	30	150	
3	K0T30	3	30	0	30	150	
4	K1T0	3	30	30	0	150	
5	K1T15	3	30	0	30	150	
6	K1T30	3	30	0	30	150	
7	K2T0	3	30	30	0	150	
8	K2T15	3	30	0	30	150	
9	K2T30	3	30	0	30	150	
10	K3T0	3	30	30	0	150	
11	K3T15	3	30	0	30	150	
12	K3T30	3	30	0	30	150	

Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (% w/w). K1 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:19:1 (% w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:18:2 (% w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3 (% w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15 %. T30 = concentration of the butterfly pea extract = 30 %.

Table 2. Quality properties of wet noodles at the various ratios of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

NB: No significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

Table 3. Pearson correlation coefficients between bioactive contents (TPC, TFC and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
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NB: The results were presented as SD of the means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .



KOT0



KOT15





K0T30



K1T0

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K1T15

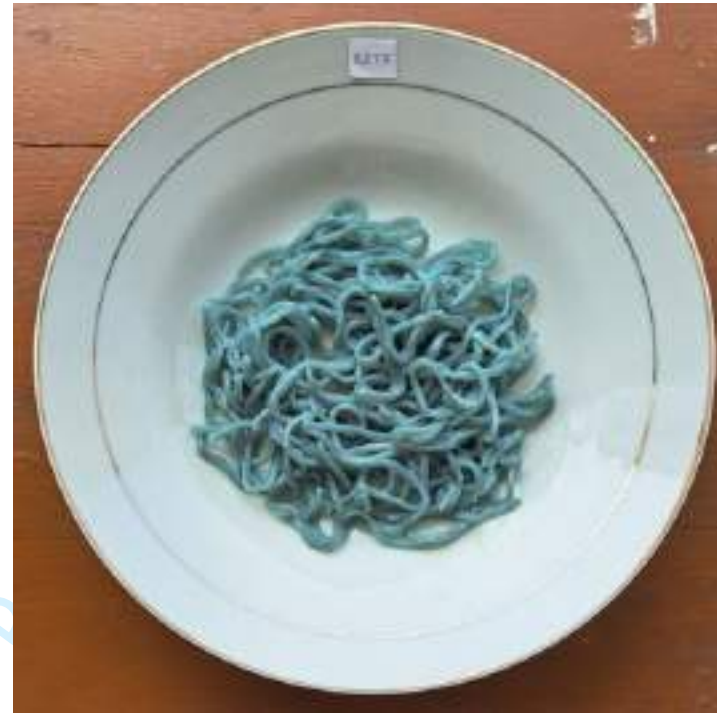


K1T30





K2T0



K2T15



K2T30



K3T0

Review Only



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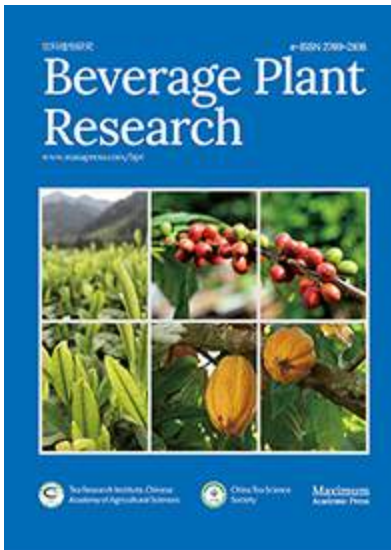
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**Effect of butterfly pea (*Clitoria ternatea*) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions**

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Keywords:	composite flour, butterfly pea flower, quality, sensory, wet noodles

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1 **Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and**  
2 **antioxidant activity of wet noodles with various composite flour proportions**

3

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11

12

**Abstract**

13 The improvement of wet noodles' qualities, sensory, and functional properties was made  
14 by using the composite flour base added with the butterfly pea flower extract. The composite  
15 flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0),  
16 80:19:1 (K1), 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentrations of  
17 butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a  
18 randomized block design with two factors, namely the composite flour and the concentration of  
19 butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30,  
20 K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the  
21 composite flour and butterfly pea flower extract significantly affected the color profile, sensory  
22 properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor  
23 also significantly influenced the physical properties of wet noodles, such as moisture content,  
24 water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to  
25 3 % (w/w) in the mixture increased moisture content, swelling index, and tensile strength but  
26 reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-  
27 stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance  
28 based on hedonic sensory score.

29 **Keywords:** composite flour, butterfly pea flower, quality, sensory, wet noodles

30

## 31 Introduction

32 The use of composite flour in wet noodles has been widely used to increase its functional  
33 value and several characteristics, including physical, chemical, and sensory properties. Siddeeg  
34 et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability  
35 of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (%  
36 w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles  
37 made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high  
38 consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the  
39 quality of wet noodles and antioxidant activity.

40 A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*)  
41 composited with wheat flour to increase the functional value of noodles by increasing biological  
42 activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending  
43 gastric emptying time.<sup>[5,6]</sup> Widyawati et al.<sup>[7]</sup> explained that using the composite flour  
44 consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index,  
45 total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl  
46 free radical scavenging activity (DPPH), which influences the effectivity of bioactive compounds  
47 in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other  
48 ingredients containing phenolic compounds can be added to increase composite flour's functional  
49 values as a source of antioxidants. Czajkowska–González et al.<sup>[8]</sup> mentioned that incorporating  
50 phenolic antioxidants from natural sources can improve the functional values of bread.  
51 Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles,  
52 however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to

53 incorporate other ingredients to enhance the wet noodles' color profile and their functional  
54 properties, one of which is the butterfly pea flower.

55 Butterfly pea (*Clitoria ternatea*) is an herb plant from the Fabaceae family with various  
56 flower colors, such as purple, blue, pink, and white <sup>[9]</sup>. This flower has phytochemical  
57 compounds that benefit as antioxidant sources <sup>[10,11]</sup>, including anthocyanins, tannins, phenolics,  
58 flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol  
59 glycosides <sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in  
60 many food products <sup>[14,15]</sup>, one of them is wet noodles <sup>[16,17]</sup>. The phytochemical compounds,  
61 especially phenolic compounds, can influence the interaction among gluten, amylose, and  
62 amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains),  
63 and benzene rings <sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds,  
64 which influenced pH and determined hydrophilic-hydrophobic properties and protein  
65 digestibility <sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant  
66 extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa* Burm.F.)<sup>[21]</sup>, carrot and  
67 beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity,  
68 and sensory properties of wet noodles. Shiau et al.<sup>[17]</sup> utilized the natural color of butterfly pea  
69 flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin,  
70 polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This  
71 extract also improved the color preference and reduced cooked noodles' cutting force, tensile  
72 strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in  
73 wet noodles has been commercially produced, but the interactions among phytochemical  
74 compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour,  
75 and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the



76 effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive  
77 content, antioxidant activity, and sensory properties.

78

## 79 **Materials and Methods**

### 80 **Raw materials and preparation**

81 Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut,  
82 Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered  
83 using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve  
84 shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group,  
85 China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95  
86 °C for 3 min based on the modified method of Widyawati et al. [20] and Purwanto et al. [24] to get  
87 three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-  
88 composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari  
89 Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat,  
90 Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratios of  
91 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### 92 **Chemical and reagents**

93 Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate  
94 were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride,  
95 Folin–Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric,  
96 sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium  
97 ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ,



98 USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya,  
99 Indonesia).

### 100 **Wet noodles preparation**

101 Wet noodles were prepared based on the modified formula of Panjaitan et al. <sup>[25]</sup>, as  
102 shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and  
103 mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole  
104 egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600  
105 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to  
106 get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone  
107 OX355AT, China) to get noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled  
108 with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before heated in  
109 boiled water (100 °C) with a ratio of raw noodles: water at 1:4 w/v for 2 min. Cooked wet  
110 noodles were coated with palm oil (Sania, PT Wilmar Nabati Indonesia) (5% w/w) before being  
111 subjected to quality and sensory properties measurements, whereas uncooked noodles without oil  
112 coating were used to analyze bioactive compounds and antioxidant activity.

### 113 **Extraction of bioactive compounds of wet noodles**

114 Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles  
115 were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia)  
116 at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set  
117 HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent  
118 mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h,  
119 and centrifuged at 5000 rpm for 5 min to obtain supernatant. The obtained residue was re-  
120 extracted in an extraction time for three intervals. The supernatant was collected and separated

121 from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210,  
122 Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The  
123 obtained extract was used for further analysis.

#### 124 **Moisture content analysis**

125 The water content of cooked wet noodles was analyzed using the thermogravimetric  
126 method [26]. About 1 g of the sample was weighed in a weighing bottle and heated in a drying  
127 oven at 105-110 °C for 1 h. The processes were followed by weighing the sample and measuring  
128 moisture content after obtaining a constant sample weight. The moisture content was calculated  
129 based on the difference of initial and obtained constant sample weight divided by the initial  
130 sample weight, expressed as a percentage of wet base.

#### 131 **Water activity analysis**

132 The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water  
133 Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed,  
134 put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity [27].

#### 135 **Tensile strength analysis**

136 Tensile strength is an essential parameter that measures the extensibility of cooked wet  
137 noodles[28]. About 20 cm of the sample was measured for its tensile strength using a texture  
138 analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT  
139 Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and  
140 post-test speed at 1 mm/s, 3 mm, and 10 mm/s, respectively. Distance, time, and trigger force  
141 were set to 100 mm, 5 sec, and 5 g, respectively.

#### 142 **Color analysis**

143 Ten grams of cooked wet noodles were weighed in a chamber, and the color was  
144 analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et  
145 al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), Hue ( $^{\circ}h$ ), and  
146 chroma ( $C$ ).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with  
147 an interval between -80 - +100.  $b^*$  value represents a yellow color with an interval of -70 - +70  
148 <sup>[30]</sup>.  $C$  indicates the color intensity and  $^{\circ}h$  states the color of samples <sup>[31]</sup>.

#### 149 **Swelling index analysis**

150 The swelling index was determined using a modified method by Islamiya et al.<sup>[32]</sup>.  
151 Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL  
152 boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of  
153 raw wet noodles to absorb water that increased the weight of raw wet noodles <sup>[33]</sup>. The swelling  
154 index was measured from the difference in noodle weights before and after boiling.

#### 155 **Cooking loss analysis**

156 The cooking loss of the raw wet noodles was analyzed using a modified method by  
157 Aditia et al. <sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking,  
158 indicated by the cooking water that turns cloudy and thick <sup>[35]</sup>. About 5 g of the raw wet noodles  
159 was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the  
160 sample was drained and dried in a drying oven at 105 °C until the weight of the sample was  
161 constant.

#### 162 **Total phenolic content analysis**

163 The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's  
164 phenol reagent based on the modified method by Eyele et al. <sup>[36]</sup>. About 50  $\mu$ L of the extract was  
165 added with 1 mL of 10 % Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask,

166 homogenized, and incubated for 5 min. Then, 2 mL of 7.5 %  $\text{Na}_2\text{CO}_3$  was added, and the  
167 volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured  
168 spectrophotometrically at  $\lambda$  760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The  
169 standard reference used was gallic acid ( $y=0.0004x+0.0287$ ,  $R^2=0.9877$ ), and the result was  
170 expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg  
171 GAE/kg dried noodles) was calculated using the equation =  $[(As-0.0287)/0.0004][2 \text{ mL}/x$   
172  $g][1L/1000mL][1000g/1kg]$ , where As=absorbance of the samples and x=weight of the dried  
173 noodles.

174

#### 175 **Total flavonoid content analysis**

176 Total flavonoid content was analyzed using the modified method by Li et al. <sup>[37]</sup>. The  
177 procedure began with mixing 0.3 mL of 5 %  $\text{NaNO}_2$  and 250  $\mu\text{L}$  of noodle extract in a 10 mL  
178 volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10 %  $\text{AlCl}_3$  was  
179 added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was  
180 adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a  
181 spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$ . 510 nm. The result  
182 was determined using a (+)-catechin standard reference ( $y=0.0008x+0.0014$ ,  $R^2=0.9999$ ) and  
183 expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg  
184 dried noodles) was calculated using the equation =  $[(As-0.0014)/0.0008][2 \text{ mL}/x$   
185  $g][1L/1000mL][1000g/1kg]$ , where As=absorbance of the samples and x=weight of the dried  
186 noodles.

187

#### 188 **Total anthocyanin content analysis**

189 Total anthocyanin content was determined using the method of Giusti and Wrolstad [38].  
 190 About 250  $\mu\text{L}$  of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10  
 191 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda$  543  
 192 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of  
 193 samples was calculated with the formula:  $A =$   
 194  $(A_{\lambda 543} - A_{\lambda 700})_{\text{pH } 1.0} - (A_{\lambda 543} - A_{\lambda 700})_{\text{pH } 4.5}$ . The total anthocyanin monomer content  
 195 (TA) (mg/mL) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times l}$ , where A was the absorbance of  
 196 samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was the  
 197 factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29000 L  
 198  $\text{cm}^{-1} \text{mol}^{-1}$ ). TA monomer (mg delphinidine-3-glucoside/kg dried noodles) was calculated using  
 199 the equation= [TA (mg/L)] [2mL/x g][1L/1000mL][1000g/1kg], where x=the weight of dried  
 200 noodles.

201

## 202 **2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity**

203 DPPH analysis was measured based on the methods of Shirazi et al. [39] and Widyawati et  
 204 al. [40]. Briefly, 10  $\mu\text{L}$  of the extract was added to a 10 mL test tube containing 3 mL of DPPH  
 205 solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The  
 206 solution was centrifuged at 5000 rpm for 5 min, and the absorbance of samples was measured at  
 207  $\lambda$  517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the  
 208 samples was stated as an inhibition capacity with gallic acid as the standard reference  
 209 ( $y=0.1405x+2.4741$ ,  $R^2=0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of  
 210 dried noodles. The percentage of DPPH free radical scavenging activity was calculated using  
 211 the equation:

212 Inhibition of DPPH free radical scavenging activity (y) (%) = [(A0-As)/A0]x 100%, where A0=  
213 absorbance of the control and As=absorbance of the samples. DPPH free radical scavenging  
214 activity (mg GAE/kg dried noodles) = [ (y-2.4741)/0.1405] [2mL/x g][1L/1000mL][1000g/1kg],  
215 where x=the weight of dried noodles.

216

### 217 **Ferric reducing antioxidant power**

218 FRAP analysis was performed using the modified method of Al-Temimi and Choundhary  
219 <sup>[41]</sup>. Approximately 50 µL of the extract in a test tube was added with 2.5 mL of phosphate buffer  
220 solution at pH 6.6 and 2.5 mL of 1 % potassium ferric cyanide, shaken and incubated for 20 min  
221 at 50 °C. After incubation, the solution was added with 2.5 ml of 10 % mono-chloroacetic acid  
222 and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5  
223 mL of bi-distilled water and 2.5 mL of 0.1 % ferric chloride and incubated for 10 min. After  
224 incubation, samples were measured with absorbance at λ 700 nm (Spectrophotometer UV-Vis  
225 1800, Shimadzu, Japan). Gallic acid was used as the standard reference (y=2.2025x-0.0144,  
226 R<sup>2</sup>=0.9983), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried  
227 noodles. The reducing power of samples was calculated using the formula:

228 The reducing power (RP) (%) = [(As-A0)/As]x 100%

229 Where A0= absorbance of the control and As=absorbance of the samples. FRAP (mg GAE/kg  
230 dried noodles) = [ (RP+0.0144)/2.2025] [2mL/x g][1L/1000mL][1000g/1kg], where x=the  
231 weight of dried noodles.

232

### 233 **Sensory evaluation**

234 The sensory properties of cooked wet noodles were analyzed based on Nugroho et al.<sup>[42]</sup>  
235 with modifications. The assessment used hedonic scale scoring with the parameters including  
236 color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very dislike, and 15  
237 was very like. This sensory analysis was performed by 100 untrained panelists between 17 and  
238 25 years old who had previously gained knowledge of the measurement procedure. Each panelist  
239 was presented with twelve (12) samples to be tested and given a questionnaire containing testing  
240 instructions and asked to give a score to each sample according to their level of liking. The  
241 hedonic scale used is a value of 1-15 given by panelists according to their level of liking for the  
242 product. A score of 1-3 indicates very dislike, a score of 4-6 does not like, a score of 7-9 is  
243 neutral, a score of 10-12 likes it, and a score of 13-15 is very like it. The best treatment was  
244 determined by the index effectiveness test <sup>[43]</sup>. The best determination was based on sensory  
245 assay which included preferences for color, aroma, taste, and texture. The principle of testing  
246 was to give a weight of 0-1 on each parameter based on the level of importance of each  
247 parameter. The higher the weight value given means the parameter was increasingly prioritized.  
248 The treatment that has the highest value was determined as the best treatment. Procedure to  
249 determining of the best treatment for wet noodles included:

250 a. Calculation of the average of the weight parameters based on the results filled in by panelists

251 b. Calculation of normal weight (BN)

252 
$$BN = \text{Variable weight} / \text{Total weight}$$

253 c. Calculation of effectiveness value (NE)

254 
$$NE = \text{Treatment value} - \text{worst value} / \text{Best value} - \text{worst value}$$

255 d. Calculation of yield value (NH)

256 
$$NH = NE \times \text{normal weight}$$

257 d. Calculation of the total productivity value of all parameters

258 Total NH = NH of color + NH of texture + NH of taste + NH of aroma

259 e. Determining the best treatment by choosing the appropriate treatment had the largest total NH

260

## 261 **Design of experiment and statistical analysis**

262 The design of experiment used was a randomized block design (RBD) with two factors,  
263 i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan)  
264 including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-  
265 butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment  
266 was performed in three replications. The homogenous triplicate data were expressed as the mean  
267  $\pm$  SD. The one-way analysis of variance (ANOVA) was done, and Duncan's New multiple range  
268 test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical  
269 analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## 270 **Results and discussions**

### 271 **Quality of Wet Noodles**

272 The quality results of the wet noodles, including moisture content, water activity, tensile  
273 strength, swelling index, cooking loss, and color, are shown in Table 2, 3, 4, dan 5, and Fig.1.  
274 Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced  
275 by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two  
276 factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the  
277 concentrations of butterfly pea extract itself did not give any significant effects on the water  
278 content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content  
279 (70 % wet base) compared to K0 (68 % wet base), K1 (68 % wet base), and K2 (69 % wet base)



280 because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan  
281 proportion influenced the amount of free and bound water in the wet noodle samples, which also  
282 increased the water content of the wet noodles. Water content resembles the amount of free and  
283 weakly bound water in the samples' pores, intermolecular, and intercellular space <sup>[7,20]</sup>. Protein  
284 networking between gliadin and glutelin forms a three-dimensional networking structure of  
285 gluten involving water molecules <sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary  
286 structure with sulfhydryl groups of gluten network to stabilize the gluten network, increasing  
287 water binding capacity and retarding the migration of water molecules <sup>[45]</sup>.  $\kappa$ -carrageenan can  
288 bind water molecules around 25-40 times <sup>[46]</sup>. The  $\kappa$ -carrageenan can cause a structure change  
289 in gluten protein through electrostatic interactions and hydrogen bonding <sup>[47]</sup>. The interaction  
290 among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour,  
291 and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure  
292 formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular disulfide  
293 bonds that can establish water mobility in the dough of the wet noodles. The interaction of all  
294 components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ )  
295 (Table 3). The addition of  $\kappa$ -carrageenan between 1-3 % in the wet noodle formulation reduced  
296 the  $A_w$  by about 0.005-0.006. The capability of  $\kappa$ -carrageenan to absorb water molecules reduces  
297 the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester  
298 sulfate groups of them to form complex structures <sup>[48]</sup>. The complexity of the reaction among  
299 components in the wet noodles to form a three-dimensional network influenced the amount of  
300 free water molecules that determined water activity values. The strength of the bonding among  
301 the components between wet noodles and water molecules also contributed to the value of the  
302 water activity.

303 Tensile strength, swelling index, and cooking loss of cooked wet noodles were  
304 significantly influenced by each factor of the ratios of composite flour or the concentrations of  
305 butterfly pea flower extract ( $p \leq 0.05$ ) (Table 3 and 4). However, the interaction between the two  
306 factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet  
307 noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour  
308 increased the tensile strength and swelling index and decreased the cooking loss of wet noodles.  
309 On the other hand, the increasing butterfly pea extract concentration decreased the tensile  
310 strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the  
311 composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the  
312 same time, incorporating butterfly pea extract caused the tensile strength of wet noodles (T15  
313 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and  
314 lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling  
315 index values of wet noodles ranged from 128 to 159 %. The effect of the composite flour  
316 proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3  
317 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of  
318 butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest  
319 cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18  
320 to 19 %.

321 Tensile strength, cooking loss, and swelling index of wet noodles were significantly  
322 influenced by the interaction of components in dough formation, namely glutelin, gliadin,  
323 glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-  
324 dimensional network structure that determined the capability of the noodle strands being  
325 resistance to break and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic

326 polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic  
327 sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages <sup>[49]</sup> that can bind water  
328 molecule to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-  
329 glucose and D-mannose that can absorb water molecules around 200 times <sup>[50]</sup> to form a strong  
330 gel that increases the viscosity and swelling index of the dough <sup>[51]</sup>. Park and Baik <sup>[52]</sup> stated that  
331 the gluten network formation affects the tensile strength of noodles. Huang et al. <sup>[48]</sup> also  
332 reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this  
333 hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not  
334 only stabilizes the structure of gluten network but also reacts with free water molecules to form a  
335 more stable three-dimensional networking structure, thus maintaining dough's rheological and  
336 tensile properties.

337         The increased swelling index of dough is caused by the capability of glucomannan to  
338 reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic  
339 interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and  
340 stable gel because of the association and lining up of the mannan molecules into the junction  
341 zones of helices <sup>[54]</sup>. The cross-linking and polymerization involving functional groups of gluten  
342 protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The  
343 stronger attraction between molecules composed of cross-linking reduces the particles or  
344 molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the  
345 protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and  
346 polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index,  
347 and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> and Widyawati et al.<sup>[7]</sup> explained that phenolic  
348 compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin)

349 and carbohydrate (amylose) to form a complex structure through many interactions, including  
350 hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking.  
351 The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan,  
352 protein, or polysaccharide and influenced complex network structure. The phenolic compounds  
353 can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -  
354 carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and  
355 noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These  
356 compounds can form complexes with protein and hydrocolloids, leading to structural and  
357 functional changes and influencing gel formation through aggregation formation and disulfide  
358 bridge breakdown <sup>[19,20,56]</sup>.

359 The color of wet noodles (Table 5 and Fig. 1) was significantly influenced by the  
360 interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ ,  
361 and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea  
362 extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0,  
363 K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased  
364 amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges  
365 were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness,  
366 and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and  
367 diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles  
368 decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30.  
369 K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The  
370 presence of  $\kappa$ -carrageenan in composite flour also supported the water-holding capacity of wet  
371 noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a

372 strong stable network that involved sulfhydryl groups. Masakuni and Konishi<sup>[57]</sup> reported that  $\kappa$ -  
373 carrageenan can associate polymer structure that involves intra-and intern molecular interaction,  
374 such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional  
375 network structure that implicated all components of composite flour was exceptionally  
376 complicated due to the involved polar and non-polar functional groups and many kinds of  
377 interaction between them. These influenced the water content and water activity of the wet  
378 noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles'  
379 color profile is anthocyanin pigment from the butterfly pea extract. Gamage et al.<sup>[58]</sup> reported that  
380 the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color.  
381 Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and  
382 chroma and also changed the hue color from yellow to green-blue color.

383 The effect of composite flour and butterfly pea extract on color was observed in chroma  
384 and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness,  
385 but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in  
386 their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky  
387 lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was  
388 yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow  
389 values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of  
390 butterfly pea extract. However, the higher concentration of butterfly pea extract lessened the  
391 green and blue colors of wet noodles made using the same proportion of composite flour. Wet  
392 noodle color is also estimated to be influenced by the phenolic compound content, which  
393 underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup>  
394 reported that the bioactive compounds in pluchea extract could change the wet noodle color

395 because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the  
396 strongest blue color due to different interactions between anthocyanin and hydrocolloid  
397 compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma  
398 values.

399

#### 400 **The phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) contents of wet** 401 **noodles**

402 The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet  
403 noodles were significantly influenced by the interaction between two parameters: the ratio of  
404 composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion  
405 of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had  
406 the highest TPC and TFC of about  $\sim 207$  mg GAE/kg dried noodles and  $\sim 57$  mg CE/kg dried  
407 noodles, respectively. The TAC of wet noodles was only influenced by the concentration of  
408 butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract  
409 addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles.  
410 In addition, based on Pearson correlation assessment, there was a strong, positive correlation  
411 between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30  
412 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of  
413 samples and the TAC at T0 ( $r = 0.153$ ) and T30 treatments ( $r = 0.067$ ), except the T15 treatment,  
414 which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles  
415 were correlated with their quality properties and antioxidant activity (AOA). The dominant  
416 anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around  $2.41$  mg/g samples<sup>[61]</sup>  
417 that has free more acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment.

418 The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a  
419 potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase  
420 pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling [63].  
421 Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids,  
422 phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol,  
423 stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol,  
424 quercetin, myricetin, 6-malonylstragalol, phenylalanine, coumaroyl sucrose, tryptophan, and  
425 coumaroyl glucose) [12,13], chlorogenic, gallic, p-coumaric, caffeic, ferulic, protocatechuic, p-  
426 hydroxy benzoic, vanillic, and syringic acids [62], ternatin anthocyanins, fatty acids, tocopherols, mome  
427 inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene [64], that  
428 contribute to the antioxidant activity [10,64]. *Clitoria ternatea* shows to exhibit antioxidant  
429 activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH)  
430 radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging  
431 activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC),  
432 superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-  
433 ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power  
434 assays [64]. The TPC and TFC of wet noodles increased along with the higher proportion of  
435 glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou  
436 et al. [65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react  
437 with Folin Ciocalteu's phenol reagent. Devaraj et al. [66] reported that 3,5-acetylalbulin is a  
438 flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

#### 439 **Antioxidant activity of wet noodles**

440 The antioxidant activity (AOA) of wet noodles was determined using DPPH radical  
441 scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6.  
442 The proportion of composite flour and the concentration of butterfly pea extracts significantly  
443 affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48  
444 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and  
445 K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the  
446 samples containing composite flour K2 with butterfly pea extracts 30 % (K2T30) had the highest  
447 DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively  
448 correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA  
449 at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$   
450 values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753,  
451 respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and  
452 T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan,  
453 phenolic compounds, amylose, gliadin, and glutelin in the dough of wet noodles determined the  
454 number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH.  
455 Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic  
456 compounds depends on the position of hydroxyl groups and the conjugated double bond of  
457 phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher  
458 levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18 and  
459 2 % (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15 % (w/w) of extract. However, the use of  
460 17 and 3 % (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30 % (w/w) of the extract showed a  
461 significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a



462 ratio of 17:3 % (w/w) was able to reduce free hydroxyl groups, which had the potential as  
463 electron or hydrogen donors in testing TPC, TFC, and DPPH.

464 FRAP of wet noodles was significantly influenced by the interaction of two parameters of  
465 the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ).  
466 FRAP was used to measure the capability of antioxidant compounds to reduce  $Fe^{3+}$  ions to  $Fe^{2+}$   
467 ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to  
468 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts  
469 (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30 % of  
470 butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed  
471 that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP  
472 activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation  
473 coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP  
474 samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table  
475 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH  
476 method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly  
477 correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability  
478 of wet noodles to scavenge free radicals was higher than them to reduce ferric ion. It proved that  
479 the bioactive compounds of wet noodles have more potential as free radical scavengers or  
480 hydrogen donors than as electron donors. Compounds that have reducing power can act as  
481 primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds acted as  
482 DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless,  
483 Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce  
484 ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and

485 positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds  
486 potential as antioxidant agents through their ability to scavenge various free radicals. The  
487 effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced  
488 by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>.  
489 Previous studies have proven that TPC and TFC significantly contribute to scavenge free  
490 radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi  
491 et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA,  
492 but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in  
493 samples determines AOA. Moreover, the polymerization or complexation of anthocyanins with  
494 other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup>  
495 informed that anthocyanins are the major groups of phenolic pigments where their antioxidant  
496 activity greatly depends on the steric hindrance of their chemical structure, such as the number  
497 and position of hydroxyl groups and the conjugated double bonds, as well as the presence of  
498 electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly  
499 and positively correlated with FRAP assay due to the role of phenolic compounds as reducing  
500 power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the  
501 phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor  
502 and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15  
503 treatment suggested that there was an interaction between the functional groups in the benzene  
504 ring in phenolic and flavonoid compounds and the functional groups in components in composite  
505 flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

## 506 **Sensory Evaluation**

507           Sensory properties of wet noodles based on the hedonic test results showed that  
508 composite flour and butterfly pea extract additions significantly influenced color, aroma, taste,  
509 and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and  
510 texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively.  
511 Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and  
512 texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities  
513 of wet noodle color that resulted in color degradation from yellow, green, to blue color,  
514 impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also informed that the addition  
515 of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet  
516 noodles was also affected by two parameters of treatments, where the results showed that the  
517 higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et  
518 al.<sup>[73]</sup> claimed that oxalic acid contained in stinky lily flour contributes to the odor of rice paper.  
519 Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stink lily flour,  
520 thereby increasing the panelists' preference for wet noodle aroma. Sumartini and Putri<sup>[74]</sup> noted  
521 that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also  
522 proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles.  
523 Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell  
524 of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed  
525 that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for  
526 wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e.,  
527 conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using  
528 butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is  
529 contributed by tannin compounds in this flower, as has been found by Handayani and

530 Kumalasari <sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also  
531 appeared to the texture preference of wet noodles. Panelists preferred wet noodles that did not  
532 break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet  
533 noodles. The results were also affected by the tensile strength of wet noodles because of the  
534 different concentrations of butterfly pea extract added to the wet noodles. The addition of  
535 butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy  
536 wet noodles <sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin,  
537 amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel <sup>[78]</sup>. Based on  
538 the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea  
539 extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

#### 540 **Conclusions**

541 Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and  
542 butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive  
543 compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin,  
544 amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional  
545 network structure that impacted moisture content, water activity, tensile strength, color, cooking  
546 loss, swelling index, bioactive content, antioxidant activity, and sensory properties of wet  
547 noodles. The higher concentration of hydrocolloid addition caused increased water content and  
548 swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly  
549 pea extracts improved color, bioactive content, and antioxidant activity and enhanced panelist  
550 preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of  
551 butterfly pea extract increased the functional value of resulting wet noodles.

552

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556

## 557 **Conflict of Interest**

558 The authors declare no conflict of interest

559

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821 Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

822 Note: K0 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour:  
823 stink lily flour:  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour:  $\kappa$ -  
824 carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour:  $\kappa$ -carrageenan = 80:17:3  
825 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15= concentration of the  
826 butterfly pea extract = 15 %. T30 = concentration of the butterfly pea extract = 30 %.

Table 2. Quality properties of wet noodles at the various ratios of composite flour and concentration of butterfly pea flower extract

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	67.64±0.27	0.971±0.009	127.45±7.15	18.71±0.13	0.108±0.007
K1T15	68.34±0.44	0.973±0.004	131.46±0.93	18.77±0.11	0.116±0.011
K1T30	68.63±1.08	0.969±0.005	141.83±8.15	19.32±0.29	0.108±0.008
K2T0	68.64±0.52	0.974±0.008	132.81±3.77	18.26±0.12	0.140±0.002
K2T15	69.57±0.59	0.973±0.004	138.12±1.18	18.43±0.06	0.138±0.006
K2T30	68.46±0.68	0.962±0.002	141.92±8.23	18.76±0.06	0.138±0.013
K3T0	69.71±0.95	0.969±0.008	155.00±4.16	17.54±0.27	0.183±0.002
K3T15	69.08±0.38	0.973±0.005	158.67±7.28	18.03±0.28	0.170±0.011
K3T30	69.76±0.80	0.970±0.005	163.66±7.52	18.33±0.03	0.161±0.002

Note: No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

Table 3. Effect of composite flour proportions on quality properties of wet noodles

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0	68.04±0.40 <sup>a</sup>	0.976±0.01 <sup>b</sup>	128.36±3.30 <sup>a</sup>	19.23±0.55 <sup>d</sup>	0.097±0.097 <sup>a</sup>
K1	68.20±0.74 <sup>a</sup>	0.971±0.01 <sup>a</sup>	133.58±8.42 <sup>b</sup>	18.93±0.34 <sup>c</sup>	0.112±0.111 <sup>b</sup>
K2	68.89±0.73 <sup>b</sup>	0.970±0.01 <sup>a</sup>	137.62±6.05 <sup>b</sup>	18.48±0.23 <sup>b</sup>	0.141±0.139 <sup>c</sup>
K3	69.52±0.73 <sup>c</sup>	0.971±0.01 <sup>a</sup>	159.11±6.77 <sup>c</sup>	17.96±0.40 <sup>a</sup>	0.173±0.171 <sup>d</sup>

Note: All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

Table 4. Effect of butterfly pea extract concentration on quality properties of wet noodles

Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
T0	68.48±0.96	0.970±0.010	135.41±12.72 <sup>a</sup>	18.35±0.57 <sup>a</sup>	0.134±0.034 <sup>b</sup>
T15	68.67±0.66	0.974±0.000	138.77±13.12 <sup>a</sup>	18.56±0.41 <sup>a</sup>	0.130±0.030 <sup>ab</sup>
T30	68.83±1.00	0.970±0.010	144.82±13.55 <sup>b</sup>	19.04±0.67 <sup>b</sup>	0.129±0.028 <sup>a</sup>

Note: All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

Table 5. Effect of interaction between composite flour and butterfly pea extract on wet noodle's color

Samples	<i>L</i> *	<i>a</i> *	<i>b</i> *	<i>C</i>	<i>h</i>
K0T0	66.10±0.30 <sup>f</sup>	0.90±0.10 <sup>f</sup>	15.70±0.10 <sup>f</sup>	15.70±0.10 <sup>f</sup>	86.60±0.20 <sup>a</sup>
K0T15	48.70±0.20 <sup>c</sup>	-11.40±0.30 <sup>bc</sup>	-3.50±0.20 <sup>c</sup>	12.00±0.30 <sup>c</sup>	197.00±0.70 <sup>c</sup>
K0T30	44.00±0.60 <sup>a</sup>	-12.80±0.20 <sup>a</sup>	-6.50±0.30 <sup>a</sup>	14.40±0.20 <sup>e</sup>	206.90±1.00 <sup>d</sup>
K1T0	67.10±0.40 <sup>f</sup>	0.90±0.20 <sup>f</sup>	15.80±0.60 <sup>f</sup>	15.80±0.60 <sup>f</sup>	86.60±0.50 <sup>a</sup>
K1T15	51.50±1.80 <sup>d</sup>	-10.80±0.40 <sup>cd</sup>	-3.00±0.20 <sup>cd</sup>	11.30±0.40 <sup>bc</sup>	195.60±0.60 <sup>c</sup>
K1T30	45.50±0.20 <sup>b</sup>	-11.80±0.80 <sup>b</sup>	-6.30±0.30 <sup>a</sup>	13.40±0.70 <sup>d</sup>	208.40±2.30 <sup>d</sup>
K2T0	67.10±0.20 <sup>f</sup>	1.00±0.10 <sup>f</sup>	16.30±0.10 <sup>fg</sup>	16.30±0.10 <sup>fg</sup>	86.40±0.10 <sup>a</sup>
K2T15	53.40±0.30 <sup>e</sup>	-10.30±0.80 <sup>de</sup>	-2.80±0.10 <sup>d</sup>	10.70±0.80 <sup>b</sup>	195.50±1.30 <sup>c</sup>
K2T30	46.00±0.40 <sup>b</sup>	-10.40±0.20 <sup>de</sup>	-6.10±0.40 <sup>a</sup>	12.10±0.40 <sup>c</sup>	210.60±1.30 <sup>e</sup>
K3T0	67.40±0.30 <sup>f</sup>	1.20±0.10 <sup>f</sup>	16.80±0.70 <sup>g</sup>	16.90±0.70 <sup>g</sup>	85.90±0.20 <sup>a</sup>
K3T15	53.80±1.30 <sup>e</sup>	-9.80±0.70 <sup>e</sup>	-1.20±0.20 <sup>e</sup>	9.90±0.70 <sup>a</sup>	187.50±1.10 <sup>b</sup>
K3T30	47.90±0.70 <sup>c</sup>	-10.10±0.40 <sup>de</sup>	-5.50±0.30 <sup>b</sup>	11.60±0.20 <sup>bc</sup>	208.40±2.30 <sup>d</sup>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

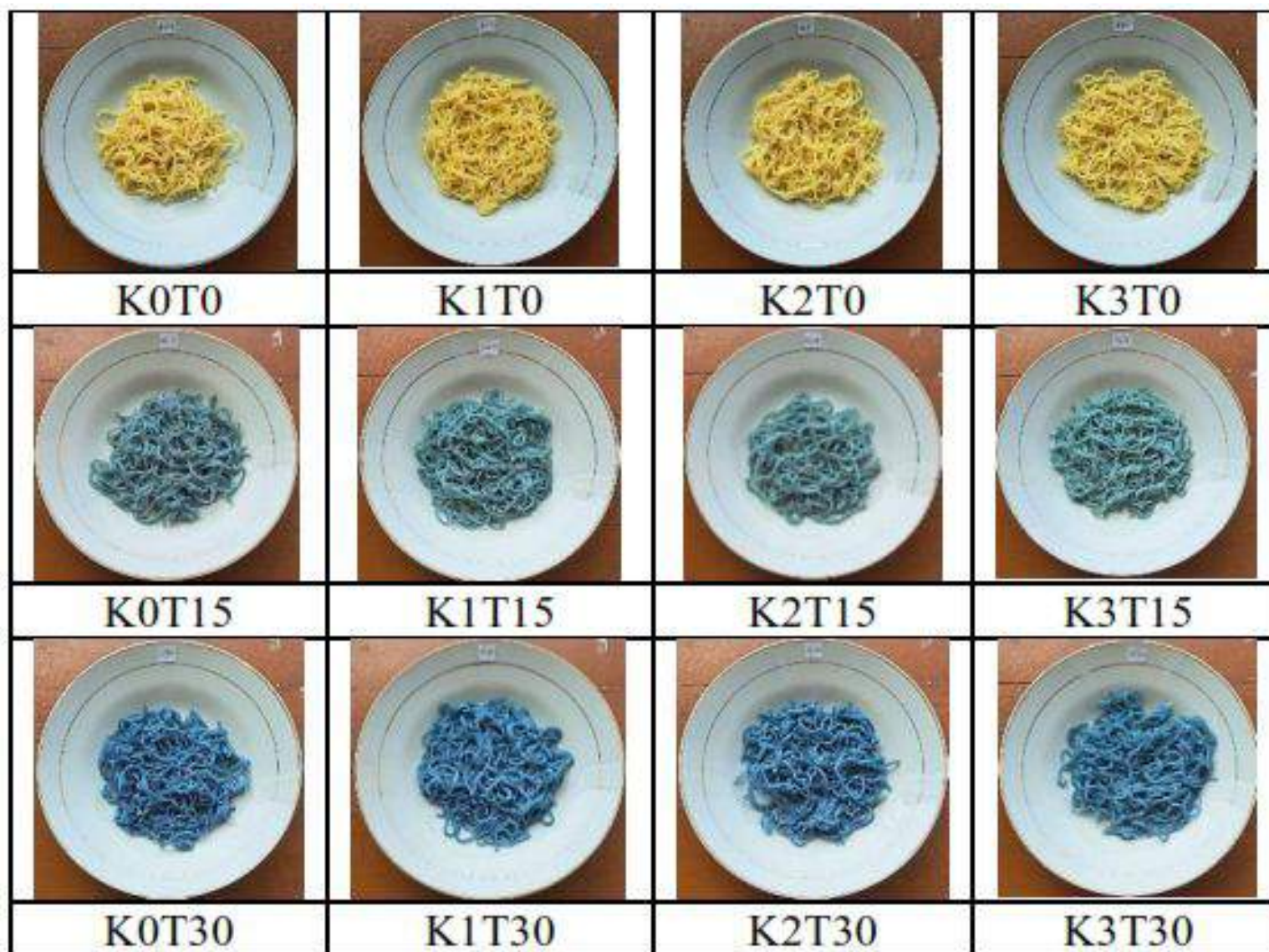


Figure 1. Color of wet noodles at various proportions of composite flour and concentrations of butterfly pea flower extract

Table 6. Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07±0.90 <sup>a</sup>	16.74±6.26 <sup>a</sup>	0.00±0.00 <sup>a</sup>	2.99±0.16 <sup>a</sup>	0.009±0.001 <sup>a</sup>
K0T15	172.57±2.14 <sup>e</sup>	36.66±2.84 <sup>d</sup>	2.67±0.21 <sup>b</sup>	21.54±1.71 <sup>d</sup>	0.023±0.002 <sup>c</sup>
K0T30	178.07±2.54 <sup>f</sup>	48.36±3.29 <sup>f</sup>	3.94±0.28 <sup>c</sup>	39.23±0.91 <sup>f</sup>	0.027±0.002 <sup>e</sup>
K1T0	137.07±1.32 <sup>b</sup>	21.66±3.67 <sup>b</sup>	0.00±0.00 <sup>a</sup>	3.13±0.19 <sup>a</sup>	0.011±0.001 <sup>a</sup>
K1T15	178.48±0.95 <sup>f</sup>	36.95±3.05 <sup>d</sup>	2.74±0.21 <sup>b</sup>	21.94±0.68 <sup>d</sup>	0.023±0.001 <sup>cd</sup>
K1T30	183.65±1.67 <sup>g</sup>	52.28±3.08 <sup>g</sup>	3.84±0.19 <sup>c</sup>	41.42±1.30 <sup>g</sup>	0.029±0.001 <sup>f</sup>
K2T0	150.40±0.52 <sup>d</sup>	27.49±5.39 <sup>c</sup>	0.00±0.00 <sup>a</sup>	7.45± 0.69 <sup>c</sup>	0.014±0.001 <sup>b</sup>
K2T15	202.48±0.63 <sup>j</sup>	48.28±2.41 <sup>f</sup>	2.95±0.57 <sup>b</sup>	24.70±0.90 <sup>e</sup>	0.025±0.001 <sup>d</sup>
K2T30	206.90±2.43 <sup>i</sup>	56.99±7.45 <sup>h</sup>	3.93±0.42 <sup>c</sup>	47.55±1.31 <sup>i</sup>	0.034±0.002 <sup>g</sup>
K3T0	141.15±1.28 <sup>c</sup>	25.37±3.46 <sup>c</sup>	0.00±0.00 <sup>a</sup>	5.45±0.49 <sup>b</sup>	0.013±0.001 <sup>b</sup>
K3T15	186.32±1.15 <sup>h</sup>	43.57±2.28 <sup>e</sup>	2.66±0.21 <sup>b</sup>	22.45±0.48 <sup>d</sup>	0.024±0.001 <sup>cd</sup>
K3T30	189.90±0.63 <sup>k</sup>	54.95±3.72 <sup>gh</sup>	3.98±0.37 <sup>c</sup>	44.93±1.28 <sup>h</sup>	0.031±0.001 <sup>f</sup>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

Table 7. Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP)

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Note: Correlation significant at the 0.05 level (2-tailed)



Table 8. Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index Effectiveness Test
K0T0	8.69±3.31 <sup>a</sup>	7.41±3.80 <sup>a</sup>	8.71±3.16 <sup>a</sup>	10.78±2.86 <sup>abcde</sup>	0.1597
K0T15	8.96±3.38 <sup>b</sup>	7.75±3.89 <sup>b</sup>	9.35±3.36 <sup>cde</sup>	11.19±3.10 <sup>abcd</sup>	0.6219
K0T30	8.93±3.50 <sup>bc</sup>	7.71±3.76 <sup>c</sup>	9.26±3.17 <sup>bcd</sup>	11.13±3.09 <sup>a</sup>	0.6691
K1T0	8.74±3.62 <sup>a</sup>	8.13±3.56 <sup>ab</sup>	9.58±3.13 <sup>ab</sup>	11.33±3.12 <sup>de</sup>	0.4339
K1T15	9.98±3.06 <sup>bc</sup>	8.40±3.28 <sup>c</sup>	10.16±2.59 <sup>def</sup>	10.61±2.82 <sup>ab</sup>	0.7086
K1T30	10.08±3.28 <sup>bc</sup>	9.10±3.08 <sup>c</sup>	10.44±2.32 <sup>bcd</sup>	10.36±2.81 <sup>ab</sup>	0.7389
K2T0	10.41±3.01 <sup>a</sup>	9.39±3.27 <sup>ab</sup>	11.04±2.44 <sup>ab</sup>	10.55±2.60 <sup>cde</sup>	0.3969
K2T15	10.8±2.85 <sup>bc</sup>	9.26±3.10 <sup>c</sup>	10.11±2.76 <sup>f</sup>	10.89±2.65 <sup>abcd</sup>	0.9219
K2T30	10.73±3.02 <sup>c</sup>	9.10±3.46 <sup>c</sup>	9.85±2.99 <sup>def</sup>	10.16±2.74 <sup>abc</sup>	0.9112
K3T0	10.73±3.42 <sup>a</sup>	9.19±3.38 <sup>b</sup>	9.93±2.50 <sup>bc</sup>	10.34±2.84 <sup>e</sup>	0.5249
K3T15	10.91±3.23 <sup>bc</sup>	9.48±3.56 <sup>c</sup>	10.45±2.82 <sup>cde</sup>	10.49±2.68 <sup>bcde</sup>	0.9235
<b>K3T30</b>	10.88±3.14 <sup>c</sup>	9.49±3.59 <sup>c</sup>	10.81±2.74 <sup>ef</sup>	10.86±2.60 <sup>bcde</sup>	<b>1.0504</b>

Note: All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscripts (alphabets) in the same column are significantly different,  $p \leq 0.05$ .

4. Paper Accepted (19-1-2024)
  - Correspondence
  - Decision Letter



Paini Sri Widyawati &lt;paini@ukwms.ac.id&gt;

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**Beverage Plant Research - Decision on Manuscript ID BPR-S2023-0041.R2**

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**Admin BPR** <onbehalf@manuscriptcentral.com>

Mon, Jan 29, 2024 at 8:50 AM

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29-Jan-2024

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Sincerely,  
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Editor-in-Chief  
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Reviewer: 1

Comments to the Author

(1) The manuscript can be accepted for publication in this journal.

(2) In the article, the font and format of equations should be unified. For the equation on Line 194; A0 on line 212, and line 228, please pay attention to the standard use of subscripts.

(3) The article lacks two parts (Author contributions and Data availability) in structure. Please add those in the author proofs stage. Please refer to "For Authors" or recent online articles, supplement to the "Author's contributions" column and "Data availability" column. [https://www.maxapress.com/bpr/for\\_authors](https://www.maxapress.com/bpr/for_authors)



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Fri, Feb 2, 2024 at 5:55 PM

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Thanks for information

Regards

Paini SW

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5. Gallery Proofreading (5-5-2024)  
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**Beverage Plant Research - Proofs for your article bpr-0024-0011 "Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions"**

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Tue, May 7, 2024 at 6:15 PM

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

**Citation:** Widyawati PS, Suseno TIP, Ivana F, Natania E, Wangtueai S. 2024. Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions. *Beverage Plant Research* <https://doi.org/10.48130/bpr-0024-0011>

## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*

Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiao et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 min based on the modified method of Widyawati et al.<sup>[20]</sup> and Purwanto et al.<sup>[24]</sup> to obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.

### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda$  760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ = \frac{As - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the

dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda$ 510 nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ = \frac{As - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda$ 543 and  $\lambda$ 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda 543} - A_{\lambda 700})_{\text{pH}1.0} - (A_{\lambda 543} - A_{\lambda 700})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times 1}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ = \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where x = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda$ 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity



$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{DPPH free radical scavenging activity (mg GAE/kg dried noodles)} = \frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choudhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 ml of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda$  700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} = \frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

- Calculation of the average of the weight parameters based on the results filled in by panelists
- Calculation of normal weight (BN)

BN = Variable weight/Total weight

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular

**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

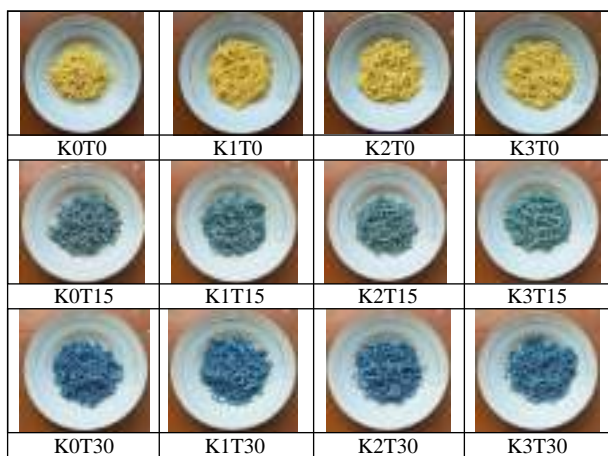
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to

absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

(T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization

involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 ± 0.30 <sup>f</sup>	0.90 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	86.60 ± 0.20 <sup>a</sup>
K0T15	48.70 ± 0.20 <sup>c</sup>	-11.40 ± 0.30 <sup>bc</sup>	-3.50 ± 0.20 <sup>c</sup>	12.00 ± 0.30 <sup>c</sup>	197.00 ± 0.70 <sup>c</sup>
K0T30	44.00 ± 0.60 <sup>a</sup>	-12.80 ± 0.20 <sup>a</sup>	-6.50 ± 0.30 <sup>a</sup>	14.40 ± 0.20 <sup>e</sup>	206.90 ± 1.00 <sup>d</sup>
K1T0	67.10 ± 0.40 <sup>f</sup>	0.90 ± 0.20 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	86.60 ± 0.50 <sup>a</sup>
K1T15	51.50 ± 1.80 <sup>d</sup>	-10.80 ± 0.40 <sup>cd</sup>	-3.00 ± 0.20 <sup>cd</sup>	11.30 ± 0.40 <sup>bc</sup>	195.60 ± 0.60 <sup>c</sup>
K1T30	45.50 ± 0.20 <sup>b</sup>	-11.80 ± 0.80 <sup>b</sup>	-6.30 ± 0.30 <sup>a</sup>	13.40 ± 0.70 <sup>d</sup>	208.40 ± 2.30 <sup>d</sup>
K2T0	67.10 ± 0.20 <sup>f</sup>	1.00 ± 0.10 <sup>f</sup>	16.30 ± 0.10 <sup>fg</sup>	16.30 ± 0.10 <sup>fg</sup>	86.40 ± 0.10 <sup>a</sup>
K2T15	53.40 ± 0.30 <sup>e</sup>	-10.30 ± 0.80 <sup>de</sup>	-2.80 ± 0.10 <sup>d</sup>	10.70 ± 0.80 <sup>b</sup>	195.50 ± 1.30 <sup>c</sup>
K2T30	46.00 ± 0.40 <sup>b</sup>	-10.40 ± 0.20 <sup>de</sup>	-6.10 ± 0.40 <sup>a</sup>	12.10 ± 0.40 <sup>c</sup>	210.60 ± 1.30 <sup>e</sup>
K3T0	67.40 ± 0.30 <sup>f</sup>	1.20 ± 0.10 <sup>f</sup>	16.80 ± 0.70 <sup>g</sup>	16.90 ± 0.70 <sup>g</sup>	85.90 ± 0.20 <sup>a</sup>
K3T15	53.80 ± 1.30 <sup>e</sup>	-9.80 ± 0.70 <sup>e</sup>	-1.20 ± 0.20 <sup>e</sup>	9.90 ± 0.70 <sup>a</sup>	187.50 ± 1.10 <sup>b</sup>
K3T30	47.90 ± 0.70 <sup>c</sup>	-10.10 ± 0.40 <sup>de</sup>	-5.50 ± 0.30 <sup>b</sup>	11.60 ± 0.20 <sup>bc</sup>	208.40 ± 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .



carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea

extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r$

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 $\pm$ 0.90 <sup>a</sup>	16.74 $\pm$ 6.26 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	2.99 $\pm$ 0.16 <sup>a</sup>	0.009 $\pm$ 0.001 <sup>a</sup>
K0T15	172.57 $\pm$ 2.14 <sup>e</sup>	36.66 $\pm$ 2.84 <sup>d</sup>	2.67 $\pm$ 0.21 <sup>b</sup>	21.54 $\pm$ 1.71 <sup>d</sup>	0.023 $\pm$ 0.002 <sup>c</sup>
K0T30	178.07 $\pm$ 2.54 <sup>f</sup>	48.36 $\pm$ 3.29 <sup>f</sup>	3.94 $\pm$ 0.28 <sup>c</sup>	39.23 $\pm$ 0.91 <sup>f</sup>	0.027 $\pm$ 0.002 <sup>e</sup>
K1T0	137.07 $\pm$ 1.32 <sup>b</sup>	21.66 $\pm$ 3.67 <sup>b</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	3.13 $\pm$ 0.19 <sup>a</sup>	0.011 $\pm$ 0.001 <sup>a</sup>
K1T15	178.48 $\pm$ 0.95 <sup>f</sup>	36.95 $\pm$ 3.05 <sup>d</sup>	2.74 $\pm$ 0.21 <sup>b</sup>	21.94 $\pm$ 0.68 <sup>d</sup>	0.023 $\pm$ 0.001 <sup>cd</sup>
K1T30	183.65 $\pm$ 1.67 <sup>g</sup>	52.28 $\pm$ 3.08 <sup>g</sup>	3.84 $\pm$ 0.19 <sup>c</sup>	41.42 $\pm$ 1.30 <sup>g</sup>	0.029 $\pm$ 0.001 <sup>f</sup>
K2T0	150.40 $\pm$ 0.52 <sup>d</sup>	27.49 $\pm$ 5.39 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	7.45 $\pm$ 0.69 <sup>c</sup>	0.014 $\pm$ 0.001 <sup>b</sup>
K2T15	202.48 $\pm$ 0.63 <sup>j</sup>	48.28 $\pm$ 2.41 <sup>f</sup>	2.95 $\pm$ 0.57 <sup>b</sup>	24.70 $\pm$ 0.90 <sup>e</sup>	0.025 $\pm$ 0.001 <sup>d</sup>
K2T30	206.90 $\pm$ 2.43 <sup>i</sup>	56.99 $\pm$ 7.45 <sup>h</sup>	3.93 $\pm$ 0.42 <sup>c</sup>	47.55 $\pm$ 1.31 <sup>i</sup>	0.034 $\pm$ 0.002 <sup>g</sup>
K3T0	141.15 $\pm$ 1.28 <sup>c</sup>	25.37 $\pm$ 3.46 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	5.45 $\pm$ 0.49 <sup>b</sup>	0.013 $\pm$ 0.001 <sup>b</sup>
K3T15	186.32 $\pm$ 1.15 <sup>h</sup>	43.57 $\pm$ 2.28 <sup>e</sup>	2.66 $\pm$ 0.21 <sup>b</sup>	22.45 $\pm$ 0.48 <sup>d</sup>	0.024 $\pm$ 0.001 <sup>cd</sup>
K3T30	189.90 $\pm$ 0.63 <sup>k</sup>	54.95 $\pm$ 3.72 <sup>gh</sup>	3.98 $\pm$ 0.37 <sup>c</sup>	44.93 $\pm$ 1.28 <sup>h</sup>	0.031 $\pm$ 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).

= 0.153) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has freed more acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds,

amylose, gliadin, and glutenin in the dough of wet noodles determined the number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymeriza-

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

tion or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists'

preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content,

antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

## Data availability

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## Conflict of interest

The authors declare that they have no conflict of interest.

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*



Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 min based on the modified method of Widyawati et al.<sup>[20]</sup> and Purwanto et al.<sup>[21]</sup> obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.

### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda_{760}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ = \frac{As - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the

dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda_{510}$  nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ = \frac{As - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda_{543}$  and  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}1.0} - (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times 1}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ = \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where x = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda_{517}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity

$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{DPPH free radical scavenging activity (mg GAE/kg dried noodles)} = \frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 mL of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} = \frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

- Calculation of the average of the weight parameters based on the results filled in by panelists
- Calculation of normal weight (BN)

BN = Variable weight/Total weight

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular

**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

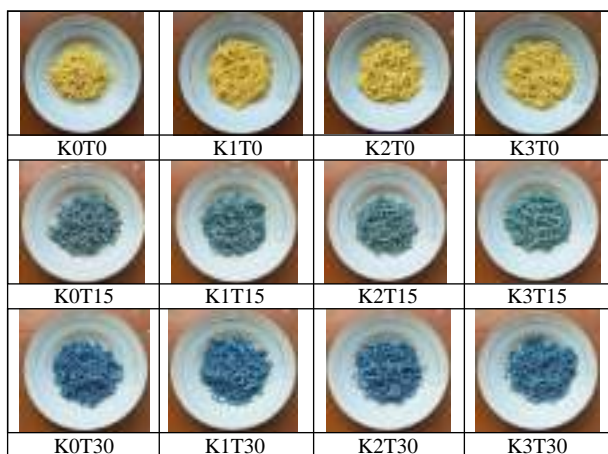
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to

absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.



(T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization

involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 ± 0.30 <sup>f</sup>	0.90 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	86.60 ± 0.20 <sup>a</sup>
K0T15	48.70 ± 0.20 <sup>c</sup>	-11.40 ± 0.30 <sup>bc</sup>	-3.50 ± 0.20 <sup>c</sup>	12.00 ± 0.30 <sup>c</sup>	197.00 ± 0.70 <sup>c</sup>
K0T30	44.00 ± 0.60 <sup>a</sup>	-12.80 ± 0.20 <sup>a</sup>	-6.50 ± 0.30 <sup>a</sup>	14.40 ± 0.20 <sup>e</sup>	206.90 ± 1.00 <sup>d</sup>
K1T0	67.10 ± 0.40 <sup>f</sup>	0.90 ± 0.20 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	86.60 ± 0.50 <sup>a</sup>
K1T15	51.50 ± 1.80 <sup>d</sup>	-10.80 ± 0.40 <sup>cd</sup>	-3.00 ± 0.20 <sup>cd</sup>	11.30 ± 0.40 <sup>bc</sup>	195.60 ± 0.60 <sup>c</sup>
K1T30	45.50 ± 0.20 <sup>b</sup>	-11.80 ± 0.80 <sup>b</sup>	-6.30 ± 0.30 <sup>a</sup>	13.40 ± 0.70 <sup>d</sup>	208.40 ± 2.30 <sup>d</sup>
K2T0	67.10 ± 0.20 <sup>f</sup>	1.00 ± 0.10 <sup>f</sup>	16.30 ± 0.10 <sup>fg</sup>	16.30 ± 0.10 <sup>fg</sup>	86.40 ± 0.10 <sup>a</sup>
K2T15	53.40 ± 0.30 <sup>e</sup>	-10.30 ± 0.80 <sup>de</sup>	-2.80 ± 0.10 <sup>d</sup>	10.70 ± 0.80 <sup>b</sup>	195.50 ± 1.30 <sup>c</sup>
K2T30	46.00 ± 0.40 <sup>b</sup>	-10.40 ± 0.20 <sup>de</sup>	-6.10 ± 0.40 <sup>a</sup>	12.10 ± 0.40 <sup>c</sup>	210.60 ± 1.30 <sup>e</sup>
K3T0	67.40 ± 0.30 <sup>f</sup>	1.20 ± 0.10 <sup>f</sup>	16.80 ± 0.70 <sup>g</sup>	16.90 ± 0.70 <sup>g</sup>	85.90 ± 0.20 <sup>a</sup>
K3T15	53.80 ± 1.30 <sup>e</sup>	-9.80 ± 0.70 <sup>e</sup>	-1.20 ± 0.20 <sup>e</sup>	9.90 ± 0.70 <sup>a</sup>	187.50 ± 1.10 <sup>b</sup>
K3T30	47.90 ± 0.70 <sup>c</sup>	-10.10 ± 0.40 <sup>de</sup>	-5.50 ± 0.30 <sup>b</sup>	11.60 ± 0.20 <sup>bc</sup>	208.40 ± 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea

extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r$

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 ± 0.90 <sup>a</sup>	16.74 ± 6.26 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	2.99 ± 0.16 <sup>a</sup>	0.009 ± 0.001 <sup>a</sup>
K0T15	172.57 ± 2.14 <sup>e</sup>	36.66 ± 2.84 <sup>d</sup>	2.67 ± 0.21 <sup>b</sup>	21.54 ± 1.71 <sup>d</sup>	0.023 ± 0.002 <sup>c</sup>
K0T30	178.07 ± 2.54 <sup>f</sup>	48.36 ± 3.29 <sup>f</sup>	3.94 ± 0.28 <sup>c</sup>	39.23 ± 0.91 <sup>f</sup>	0.027 ± 0.002 <sup>e</sup>
K1T0	137.07 ± 1.32 <sup>b</sup>	21.66 ± 3.67 <sup>b</sup>	0.00 ± 0.00 <sup>a</sup>	3.13 ± 0.19 <sup>a</sup>	0.011 ± 0.001 <sup>a</sup>
K1T15	178.48 ± 0.95 <sup>f</sup>	36.95 ± 3.05 <sup>d</sup>	2.74 ± 0.21 <sup>b</sup>	21.94 ± 0.68 <sup>d</sup>	0.023 ± 0.001 <sup>cd</sup>
K1T30	183.65 ± 1.67 <sup>g</sup>	52.28 ± 3.08 <sup>g</sup>	3.84 ± 0.19 <sup>c</sup>	41.42 ± 1.30 <sup>g</sup>	0.029 ± 0.001 <sup>f</sup>
K2T0	150.40 ± 0.52 <sup>d</sup>	27.49 ± 5.39 <sup>c</sup>	0.00 ± 0.00 <sup>a</sup>	7.45 ± 0.69 <sup>c</sup>	0.014 ± 0.001 <sup>b</sup>
K2T15	202.48 ± 0.63 <sup>j</sup>	48.28 ± 2.41 <sup>f</sup>	2.95 ± 0.57 <sup>b</sup>	24.70 ± 0.90 <sup>e</sup>	0.025 ± 0.001 <sup>d</sup>
K2T30	206.90 ± 2.43 <sup>i</sup>	56.99 ± 7.45 <sup>h</sup>	3.93 ± 0.42 <sup>c</sup>	47.55 ± 1.31 <sup>i</sup>	0.034 ± 0.002 <sup>g</sup>
K3T0	141.15 ± 1.28 <sup>c</sup>	25.37 ± 3.46 <sup>c</sup>	0.00 ± 0.00 <sup>a</sup>	5.45 ± 0.49 <sup>b</sup>	0.013 ± 0.001 <sup>b</sup>
K3T15	186.32 ± 1.15 <sup>h</sup>	43.57 ± 2.28 <sup>e</sup>	2.66 ± 0.21 <sup>b</sup>	22.45 ± 0.48 <sup>d</sup>	0.024 ± 0.001 <sup>cd</sup>
K3T30	189.90 ± 0.63 <sup>k</sup>	54.95 ± 3.72 <sup>gh</sup>	3.98 ± 0.37 <sup>c</sup>	44.93 ± 1.28 <sup>h</sup>	0.031 ± 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).

= 0.153) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has more free acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds,

amylose, gliadin, and glutenin in the dough of wet noodles determined the number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymeriza-

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

tion or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists'

preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content,



antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

The authors confirm contribution to the paper as follows: study conception and design, literature search, methodologies of the lab analyses design: Widyawati PS, Suseno TIP; Fieldwork implementation, data collection, analysis and interpretation of results: Widyawati PS, Ivana F, Natania E; draft manuscript preparation: Widyawati PS; Manuscript revision: Wangtueai S. All authors reviewed the results and approved the final version of the manuscript.

## Data availability

Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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## Composite flour-butterfly pea flower

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DeGarmo EP, Sullivan WG, Candra CR. 1984. *Engineering Economy*. 7<sup>th</sup> Edition. London: Macmillan Publ. Co.

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Poli AR, Katja DG, Aritonang HF. 2022. Potency of antioxidant extract from matoa seed coat (*Pometia pinnata* J. R & G. Forst). *Chemistry Progress* 15(1):25–30. Available online : <https://ejournal.unsrat.ac.id/v3/index.php/chemprog/article/view/43151/37970>

### Queries 15. Contribution of Author

P.S.W. and T.I.P.S. conceived the research; P.S.W. and T.I.P.S. carried out the literature search and designed the methodologies of the lab analyses; P.S.W., F.I. and E.N. implemented the fieldwork; P.S.W., F.I. and E.N. performed the experiments and processed the raw data; P.S.W., F.I. and E.N. processed the data and performed the data analyses; P.S.W. wrote the manuscript; S.W. proofread writing the manuscript.

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Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

### Queries 17. Grant Funding

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### Queries 18. Check all references

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Siddeeg A, Salih ZA, Ammar A, Almahi RAY, Ali AO. 2018. Production of noodles from composite flour and its nutrition sensory characteristics. *Chinese Journal of Medical Research* 1(1):03–07. <http://dx.doi.org/10.37515/cjmr.091X.1102>

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Purwanto UMS, Aprilia K, Sulistiyani. 2022. Antioxidant activity of telang (*Clitoria ternatea* L.) extract in inhibiting lipid peroxidation. *Current Biochemistry* 9(1):26–37. <https://doi.org/10.29244/cb.9.1.3>

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

Paini Sri Widyawati<sup>1\*</sup>, Thomas Indarto Putut Suseno<sup>1</sup>, Felicia Ivana<sup>1</sup>, Evelyne Natania<sup>1</sup> and Sutee Wangtueai<sup>2</sup>

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<sup>2</sup> College of Maritime Studies and Management, Chiang Mai University, Samut Sakhon 74000, Thailand

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

**Citation:** Widyawati PS, Suseno TIP, Ivana F, Natania E, Wangtueai S. 2024. Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions. *Beverage Plant Research* <https://doi.org/10.48130/bpr-0024-0011>

## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*

Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiao et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 min based on the modified method of Widyawati et al.<sup>[20]</sup> and Purwanto et al.<sup>[24]</sup> to obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembang, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.



### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda_{760}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ = \frac{As - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the

dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda_{510}$  nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ = \frac{As - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda_{543}$  and  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}1.0} - (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times l}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ = \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where x = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda_{517}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity



$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{DPPH free radical scavenging activity (mg GAE/kg dried noodles)} = \frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 ml of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} = \frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

- Calculation of the average of the weight parameters based on the results filled in by panelists
- Calculation of normal weight (BN)

BN = Variable weight/Total weight

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular

**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

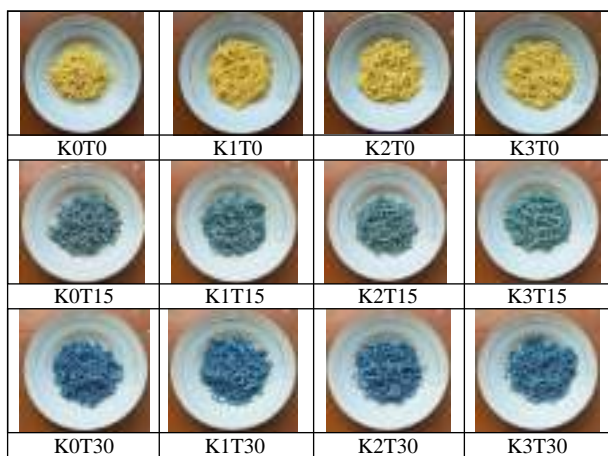
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to

absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

(T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization

involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 ± 0.30 <sup>f</sup>	0.90 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	86.60 ± 0.20 <sup>a</sup>
K0T15	48.70 ± 0.20 <sup>c</sup>	-11.40 ± 0.30 <sup>bc</sup>	-3.50 ± 0.20 <sup>c</sup>	12.00 ± 0.30 <sup>c</sup>	197.00 ± 0.70 <sup>c</sup>
K0T30	44.00 ± 0.60 <sup>a</sup>	-12.80 ± 0.20 <sup>a</sup>	-6.50 ± 0.30 <sup>a</sup>	14.40 ± 0.20 <sup>e</sup>	206.90 ± 1.00 <sup>d</sup>
K1T0	67.10 ± 0.40 <sup>f</sup>	0.90 ± 0.20 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	86.60 ± 0.50 <sup>a</sup>
K1T15	51.50 ± 1.80 <sup>d</sup>	-10.80 ± 0.40 <sup>cd</sup>	-3.00 ± 0.20 <sup>cd</sup>	11.30 ± 0.40 <sup>bc</sup>	195.60 ± 0.60 <sup>c</sup>
K1T30	45.50 ± 0.20 <sup>b</sup>	-11.80 ± 0.80 <sup>b</sup>	-6.30 ± 0.30 <sup>a</sup>	13.40 ± 0.70 <sup>d</sup>	208.40 ± 2.30 <sup>d</sup>
K2T0	67.10 ± 0.20 <sup>f</sup>	1.00 ± 0.10 <sup>f</sup>	16.30 ± 0.10 <sup>fg</sup>	16.30 ± 0.10 <sup>fg</sup>	86.40 ± 0.10 <sup>a</sup>
K2T15	53.40 ± 0.30 <sup>e</sup>	-10.30 ± 0.80 <sup>de</sup>	-2.80 ± 0.10 <sup>d</sup>	10.70 ± 0.80 <sup>b</sup>	195.50 ± 1.30 <sup>c</sup>
K2T30	46.00 ± 0.40 <sup>b</sup>	-10.40 ± 0.20 <sup>de</sup>	-6.10 ± 0.40 <sup>a</sup>	12.10 ± 0.40 <sup>c</sup>	210.60 ± 1.30 <sup>e</sup>
K3T0	67.40 ± 0.30 <sup>f</sup>	1.20 ± 0.10 <sup>f</sup>	16.80 ± 0.70 <sup>g</sup>	16.90 ± 0.70 <sup>g</sup>	85.90 ± 0.20 <sup>a</sup>
K3T15	53.80 ± 1.30 <sup>e</sup>	-9.80 ± 0.70 <sup>e</sup>	-1.20 ± 0.20 <sup>e</sup>	9.90 ± 0.70 <sup>a</sup>	187.50 ± 1.10 <sup>b</sup>
K3T30	47.90 ± 0.70 <sup>c</sup>	-10.10 ± 0.40 <sup>de</sup>	-5.50 ± 0.30 <sup>b</sup>	11.60 ± 0.20 <sup>bc</sup>	208.40 ± 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea

extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r$

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 ± 0.90 <sup>a</sup>	16.74 ± 6.26 <sup>a</sup>	0.00 ± 0.00 <sup>a</sup>	2.99 ± 0.16 <sup>a</sup>	0.009 ± 0.001 <sup>a</sup>
K0T15	172.57 ± 2.14 <sup>e</sup>	36.66 ± 2.84 <sup>d</sup>	2.67 ± 0.21 <sup>b</sup>	21.54 ± 1.71 <sup>d</sup>	0.023 ± 0.002 <sup>c</sup>
K0T30	178.07 ± 2.54 <sup>f</sup>	48.36 ± 3.29 <sup>f</sup>	3.94 ± 0.28 <sup>c</sup>	39.23 ± 0.91 <sup>f</sup>	0.027 ± 0.002 <sup>e</sup>
K1T0	137.07 ± 1.32 <sup>b</sup>	21.66 ± 3.67 <sup>b</sup>	0.00 ± 0.00 <sup>a</sup>	3.13 ± 0.19 <sup>a</sup>	0.011 ± 0.001 <sup>a</sup>
K1T15	178.48 ± 0.95 <sup>f</sup>	36.95 ± 3.05 <sup>d</sup>	2.74 ± 0.21 <sup>b</sup>	21.94 ± 0.68 <sup>d</sup>	0.023 ± 0.001 <sup>cd</sup>
K1T30	183.65 ± 1.67 <sup>g</sup>	52.28 ± 3.08 <sup>g</sup>	3.84 ± 0.19 <sup>c</sup>	41.42 ± 1.30 <sup>g</sup>	0.029 ± 0.001 <sup>f</sup>
K2T0	150.40 ± 0.52 <sup>d</sup>	27.49 ± 5.39 <sup>c</sup>	0.00 ± 0.00 <sup>a</sup>	7.45 ± 0.69 <sup>c</sup>	0.014 ± 0.001 <sup>b</sup>
K2T15	202.48 ± 0.63 <sup>j</sup>	48.28 ± 2.41 <sup>f</sup>	2.95 ± 0.57 <sup>b</sup>	24.70 ± 0.90 <sup>e</sup>	0.025 ± 0.001 <sup>d</sup>
K2T30	206.90 ± 2.43 <sup>i</sup>	56.99 ± 7.45 <sup>h</sup>	3.93 ± 0.42 <sup>c</sup>	47.55 ± 1.31 <sup>i</sup>	0.034 ± 0.002 <sup>g</sup>
K3T0	141.15 ± 1.28 <sup>c</sup>	25.37 ± 3.46 <sup>c</sup>	0.00 ± 0.00 <sup>a</sup>	5.45 ± 0.49 <sup>b</sup>	0.013 ± 0.001 <sup>b</sup>
K3T15	186.32 ± 1.15 <sup>h</sup>	43.57 ± 2.28 <sup>e</sup>	2.66 ± 0.21 <sup>b</sup>	22.45 ± 0.48 <sup>d</sup>	0.024 ± 0.001 <sup>cd</sup>
K3T30	189.90 ± 0.63 <sup>k</sup>	54.95 ± 3.72 <sup>gh</sup>	3.98 ± 0.37 <sup>c</sup>	44.93 ± 1.28 <sup>h</sup>	0.031 ± 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).



= 0.153) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has more free acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric, caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds,

amylose, gliadin, and glutenin in the dough of wet noodles determined the number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymeriza-

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

tion or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists'

preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content,

antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

The authors confirm contribution to the paper as follows: study conception and design, literature search, methodologies of the lab analyses design: Widyawati PS, Suseno TIP; Fieldwork implementation, data collection, analysis and interpretation of results: Widyawati PS, Ivana F, Natania E; draft manuscript preparation: Widyawati PS; Manuscript revision: Wangtueai S. All authors reviewed the results and approved the final version of the manuscript.

## Data availability

Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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## Composite flour-butterfly pea flower

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*

Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 min based on the modified method of Widyawati et al.<sup>[20]</sup> and Purwanto et al.<sup>[21]</sup> obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.

### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda_{760}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ = \frac{As - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the

dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda_{510}$  nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ = \frac{As - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda_{543}$  and  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}1.0} - (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times 1}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ = \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where x = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda_{517}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity



$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{DPPH free radical scavenging activity (mg GAE/kg dried noodles)} = \frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 ml of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} = \frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

- Calculation of the average of the weight parameters based on the results filled in by panelists
- Calculation of normal weight (BN)

BN = Variable weight/Total weight

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular

**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

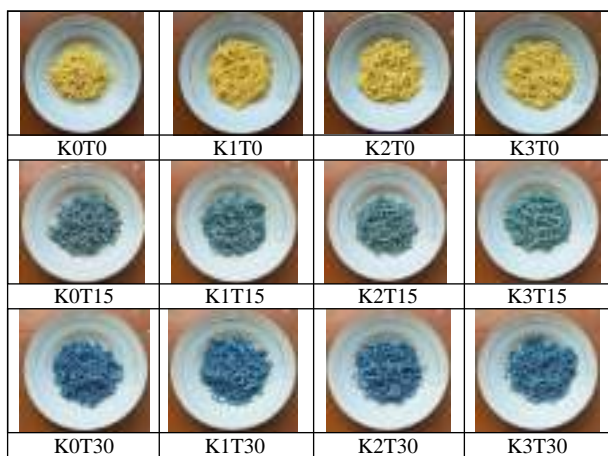
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to

absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

(T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization

involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 ± 0.30 <sup>f</sup>	0.90 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	15.70 ± 0.10 <sup>f</sup>	86.60 ± 0.20 <sup>a</sup>
K0T15	48.70 ± 0.20 <sup>c</sup>	-11.40 ± 0.30 <sup>bc</sup>	-3.50 ± 0.20 <sup>c</sup>	12.00 ± 0.30 <sup>c</sup>	197.00 ± 0.70 <sup>c</sup>
K0T30	44.00 ± 0.60 <sup>a</sup>	-12.80 ± 0.20 <sup>a</sup>	-6.50 ± 0.30 <sup>a</sup>	14.40 ± 0.20 <sup>e</sup>	206.90 ± 1.00 <sup>d</sup>
K1T0	67.10 ± 0.40 <sup>f</sup>	0.90 ± 0.20 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	15.80 ± 0.60 <sup>f</sup>	86.60 ± 0.50 <sup>a</sup>
K1T15	51.50 ± 1.80 <sup>d</sup>	-10.80 ± 0.40 <sup>cd</sup>	-3.00 ± 0.20 <sup>cd</sup>	11.30 ± 0.40 <sup>bc</sup>	195.60 ± 0.60 <sup>c</sup>
K1T30	45.50 ± 0.20 <sup>b</sup>	-11.80 ± 0.80 <sup>b</sup>	-6.30 ± 0.30 <sup>a</sup>	13.40 ± 0.70 <sup>d</sup>	208.40 ± 2.30 <sup>d</sup>
K2T0	67.10 ± 0.20 <sup>f</sup>	1.00 ± 0.10 <sup>f</sup>	16.30 ± 0.10 <sup>fg</sup>	16.30 ± 0.10 <sup>fg</sup>	86.40 ± 0.10 <sup>a</sup>
K2T15	53.40 ± 0.30 <sup>e</sup>	-10.30 ± 0.80 <sup>de</sup>	-2.80 ± 0.10 <sup>d</sup>	10.70 ± 0.80 <sup>b</sup>	195.50 ± 1.30 <sup>c</sup>
K2T30	46.00 ± 0.40 <sup>b</sup>	-10.40 ± 0.20 <sup>de</sup>	-6.10 ± 0.40 <sup>a</sup>	12.10 ± 0.40 <sup>c</sup>	210.60 ± 1.30 <sup>e</sup>
K3T0	67.40 ± 0.30 <sup>f</sup>	1.20 ± 0.10 <sup>f</sup>	16.80 ± 0.70 <sup>g</sup>	16.90 ± 0.70 <sup>g</sup>	85.90 ± 0.20 <sup>a</sup>
K3T15	53.80 ± 1.30 <sup>e</sup>	-9.80 ± 0.70 <sup>e</sup>	-1.20 ± 0.20 <sup>e</sup>	9.90 ± 0.70 <sup>a</sup>	187.50 ± 1.10 <sup>b</sup>
K3T30	47.90 ± 0.70 <sup>c</sup>	-10.10 ± 0.40 <sup>de</sup>	-5.50 ± 0.30 <sup>b</sup>	11.60 ± 0.20 <sup>bc</sup>	208.40 ± 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .



carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea

extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r$

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 $\pm$ 0.90 <sup>a</sup>	16.74 $\pm$ 6.26 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	2.99 $\pm$ 0.16 <sup>a</sup>	0.009 $\pm$ 0.001 <sup>a</sup>
K0T15	172.57 $\pm$ 2.14 <sup>e</sup>	36.66 $\pm$ 2.84 <sup>d</sup>	2.67 $\pm$ 0.21 <sup>b</sup>	21.54 $\pm$ 1.71 <sup>d</sup>	0.023 $\pm$ 0.002 <sup>c</sup>
K0T30	178.07 $\pm$ 2.54 <sup>f</sup>	48.36 $\pm$ 3.29 <sup>f</sup>	3.94 $\pm$ 0.28 <sup>c</sup>	39.23 $\pm$ 0.91 <sup>f</sup>	0.027 $\pm$ 0.002 <sup>e</sup>
K1T0	137.07 $\pm$ 1.32 <sup>b</sup>	21.66 $\pm$ 3.67 <sup>b</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	3.13 $\pm$ 0.19 <sup>a</sup>	0.011 $\pm$ 0.001 <sup>a</sup>
K1T15	178.48 $\pm$ 0.95 <sup>f</sup>	36.95 $\pm$ 3.05 <sup>d</sup>	2.74 $\pm$ 0.21 <sup>b</sup>	21.94 $\pm$ 0.68 <sup>d</sup>	0.023 $\pm$ 0.001 <sup>cd</sup>
K1T30	183.65 $\pm$ 1.67 <sup>g</sup>	52.28 $\pm$ 3.08 <sup>g</sup>	3.84 $\pm$ 0.19 <sup>c</sup>	41.42 $\pm$ 1.30 <sup>g</sup>	0.029 $\pm$ 0.001 <sup>f</sup>
K2T0	150.40 $\pm$ 0.52 <sup>d</sup>	27.49 $\pm$ 5.39 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	7.45 $\pm$ 0.69 <sup>c</sup>	0.014 $\pm$ 0.001 <sup>b</sup>
K2T15	202.48 $\pm$ 0.63 <sup>j</sup>	48.28 $\pm$ 2.41 <sup>f</sup>	2.95 $\pm$ 0.57 <sup>b</sup>	24.70 $\pm$ 0.90 <sup>e</sup>	0.025 $\pm$ 0.001 <sup>d</sup>
K2T30	206.90 $\pm$ 2.43 <sup>i</sup>	56.99 $\pm$ 7.45 <sup>h</sup>	3.93 $\pm$ 0.42 <sup>c</sup>	47.55 $\pm$ 1.31 <sup>i</sup>	0.034 $\pm$ 0.002 <sup>g</sup>
K3T0	141.15 $\pm$ 1.28 <sup>c</sup>	25.37 $\pm$ 3.46 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	5.45 $\pm$ 0.49 <sup>b</sup>	0.013 $\pm$ 0.001 <sup>b</sup>
K3T15	186.32 $\pm$ 1.15 <sup>h</sup>	43.57 $\pm$ 2.28 <sup>e</sup>	2.66 $\pm$ 0.21 <sup>b</sup>	22.45 $\pm$ 0.48 <sup>d</sup>	0.024 $\pm$ 0.001 <sup>cd</sup>
K3T30	189.90 $\pm$ 0.63 <sup>k</sup>	54.95 $\pm$ 3.72 <sup>gh</sup>	3.98 $\pm$ 0.37 <sup>c</sup>	44.93 $\pm$ 1.28 <sup>h</sup>	0.031 $\pm$ 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).

= 0.153) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has more free acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric, caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds,

amylose, gliadin, and glutenin in the dough of wet noodles determined the number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymeriza-

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

tion or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists'

preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content,

antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

The authors confirm contribution to the paper as follows: study conception and design, literature search, methodologies of the lab analyses design: Widyawati PS, Suseno TIP; Fieldwork implementation, data collection, analysis and interpretation of results: Widyawati PS, Ivana F, Natania E; draft manuscript preparation: Widyawati PS; Manuscript revision: Wangtueai S. All authors reviewed the results and approved the final version of the manuscript.

## Data availability

Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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## Composite flour-butterfly pea flower

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*



Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 h based on the modified method of Widyawati et al.<sup>[20]</sup> and Purnawanto et al.<sup>[24]</sup> to obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembang, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.

### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda_{760}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ = \frac{As - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the

dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda_{510}$  nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ = \frac{As - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where As = absorbance of the samples, and x = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda_{543}$  and  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}1.0} - (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times 1}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ = \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where x = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda_{517}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity

$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{DPPH free radical scavenging activity (mg GAE/kg dried noodles)} = \frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 mL of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} = \frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

- Calculation of the average of the weight parameters based on the results filled in by panelists
- Calculation of normal weight (BN)

BN = Variable weight/Total weight

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra-and inter-molecular

**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

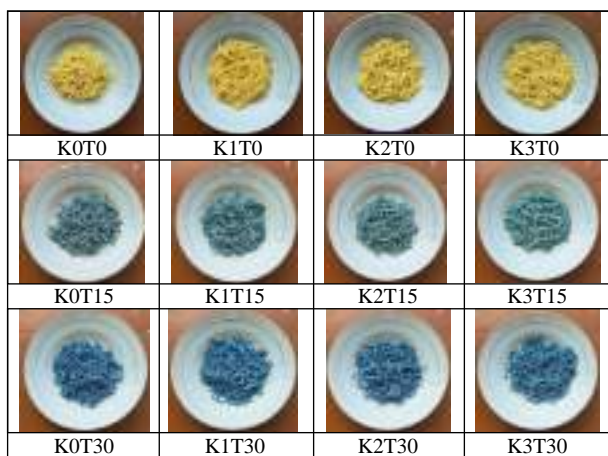
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to

absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.



(T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization

involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other. The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 $\pm$ 0.30 <sup>f</sup>	0.90 $\pm$ 0.10 <sup>f</sup>	15.70 $\pm$ 0.10 <sup>f</sup>	15.70 $\pm$ 0.10 <sup>f</sup>	86.60 $\pm$ 0.20 <sup>a</sup>
K0T15	48.70 $\pm$ 0.20 <sup>c</sup>	-11.40 $\pm$ 0.30 <sup>bc</sup>	-3.50 $\pm$ 0.20 <sup>c</sup>	12.00 $\pm$ 0.30 <sup>c</sup>	197.00 $\pm$ 0.70 <sup>c</sup>
K0T30	44.00 $\pm$ 0.60 <sup>a</sup>	-12.80 $\pm$ 0.20 <sup>a</sup>	-6.50 $\pm$ 0.30 <sup>a</sup>	14.40 $\pm$ 0.20 <sup>e</sup>	206.90 $\pm$ 1.00 <sup>d</sup>
K1T0	67.10 $\pm$ 0.40 <sup>f</sup>	0.90 $\pm$ 0.20 <sup>f</sup>	15.80 $\pm$ 0.60 <sup>f</sup>	15.80 $\pm$ 0.60 <sup>f</sup>	86.60 $\pm$ 0.50 <sup>a</sup>
K1T15	51.50 $\pm$ 1.80 <sup>d</sup>	-10.80 $\pm$ 0.40 <sup>cd</sup>	-3.00 $\pm$ 0.20 <sup>cd</sup>	11.30 $\pm$ 0.40 <sup>bc</sup>	195.60 $\pm$ 0.60 <sup>c</sup>
K1T30	45.50 $\pm$ 0.20 <sup>b</sup>	-11.80 $\pm$ 0.80 <sup>b</sup>	-6.30 $\pm$ 0.30 <sup>a</sup>	13.40 $\pm$ 0.70 <sup>d</sup>	208.40 $\pm$ 2.30 <sup>d</sup>
K2T0	67.10 $\pm$ 0.20 <sup>f</sup>	1.00 $\pm$ 0.10 <sup>f</sup>	16.30 $\pm$ 0.10 <sup>fg</sup>	16.30 $\pm$ 0.10 <sup>fg</sup>	86.40 $\pm$ 0.10 <sup>a</sup>
K2T15	53.40 $\pm$ 0.30 <sup>e</sup>	-10.30 $\pm$ 0.80 <sup>de</sup>	-2.80 $\pm$ 0.10 <sup>d</sup>	10.70 $\pm$ 0.80 <sup>b</sup>	195.50 $\pm$ 1.30 <sup>c</sup>
K2T30	46.00 $\pm$ 0.40 <sup>b</sup>	-10.40 $\pm$ 0.20 <sup>de</sup>	-6.10 $\pm$ 0.40 <sup>a</sup>	12.10 $\pm$ 0.40 <sup>c</sup>	210.60 $\pm$ 1.30 <sup>e</sup>
K3T0	67.40 $\pm$ 0.30 <sup>f</sup>	1.20 $\pm$ 0.10 <sup>f</sup>	16.80 $\pm$ 0.70 <sup>g</sup>	16.90 $\pm$ 0.70 <sup>g</sup>	85.90 $\pm$ 0.20 <sup>a</sup>
K3T15	53.80 $\pm$ 1.30 <sup>e</sup>	-9.80 $\pm$ 0.70 <sup>e</sup>	-1.20 $\pm$ 0.20 <sup>e</sup>	9.90 $\pm$ 0.70 <sup>a</sup>	187.50 $\pm$ 1.10 <sup>b</sup>
K3T30	47.90 $\pm$ 0.70 <sup>c</sup>	-10.10 $\pm$ 0.40 <sup>de</sup>	-5.50 $\pm$ 0.30 <sup>b</sup>	11.60 $\pm$ 0.20 <sup>bc</sup>	208.40 $\pm$ 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea

extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r$

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 $\pm$ 0.90 <sup>a</sup>	16.74 $\pm$ 6.26 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	2.99 $\pm$ 0.16 <sup>a</sup>	0.009 $\pm$ 0.001 <sup>a</sup>
K0T15	172.57 $\pm$ 2.14 <sup>e</sup>	36.66 $\pm$ 2.84 <sup>d</sup>	2.67 $\pm$ 0.21 <sup>b</sup>	21.54 $\pm$ 1.71 <sup>d</sup>	0.023 $\pm$ 0.002 <sup>c</sup>
K0T30	178.07 $\pm$ 2.54 <sup>f</sup>	48.36 $\pm$ 3.29 <sup>f</sup>	3.94 $\pm$ 0.28 <sup>c</sup>	39.23 $\pm$ 0.91 <sup>f</sup>	0.027 $\pm$ 0.002 <sup>e</sup>
K1T0	137.07 $\pm$ 1.32 <sup>b</sup>	21.66 $\pm$ 3.67 <sup>b</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	3.13 $\pm$ 0.19 <sup>a</sup>	0.011 $\pm$ 0.001 <sup>a</sup>
K1T15	178.48 $\pm$ 0.95 <sup>f</sup>	36.95 $\pm$ 3.05 <sup>d</sup>	2.74 $\pm$ 0.21 <sup>b</sup>	21.94 $\pm$ 0.68 <sup>d</sup>	0.023 $\pm$ 0.001 <sup>cd</sup>
K1T30	183.65 $\pm$ 1.67 <sup>g</sup>	52.28 $\pm$ 3.08 <sup>g</sup>	3.84 $\pm$ 0.19 <sup>c</sup>	41.42 $\pm$ 1.30 <sup>g</sup>	0.029 $\pm$ 0.001 <sup>f</sup>
K2T0	150.40 $\pm$ 0.52 <sup>d</sup>	27.49 $\pm$ 5.39 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	7.45 $\pm$ 0.69 <sup>c</sup>	0.014 $\pm$ 0.001 <sup>b</sup>
K2T15	202.48 $\pm$ 0.63 <sup>j</sup>	48.28 $\pm$ 2.41 <sup>f</sup>	2.95 $\pm$ 0.57 <sup>b</sup>	24.70 $\pm$ 0.90 <sup>e</sup>	0.025 $\pm$ 0.001 <sup>d</sup>
K2T30	206.90 $\pm$ 2.43 <sup>i</sup>	56.99 $\pm$ 7.45 <sup>h</sup>	3.93 $\pm$ 0.42 <sup>c</sup>	47.55 $\pm$ 1.31 <sup>i</sup>	0.034 $\pm$ 0.002 <sup>g</sup>
K3T0	141.15 $\pm$ 1.28 <sup>c</sup>	25.37 $\pm$ 3.46 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	5.45 $\pm$ 0.49 <sup>b</sup>	0.013 $\pm$ 0.001 <sup>b</sup>
K3T15	186.32 $\pm$ 1.15 <sup>h</sup>	43.57 $\pm$ 2.28 <sup>e</sup>	2.66 $\pm$ 0.21 <sup>b</sup>	22.45 $\pm$ 0.48 <sup>d</sup>	0.024 $\pm$ 0.001 <sup>cd</sup>
K3T30	189.90 $\pm$ 0.63 <sup>k</sup>	54.95 $\pm$ 3.72 <sup>gh</sup>	3.98 $\pm$ 0.37 <sup>c</sup>	44.93 $\pm$ 1.28 <sup>h</sup>	0.031 $\pm$ 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).

= 0.153) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7). The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has more free acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and  $\text{Cu}^{2+}$  reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with  $\text{AlCl}_3$ .

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds,

amylose, gliadin, and glutenin in the dough of wet noodles determined the number and position of free hydroxyl groups that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce  $\text{Fe}^{3+}$  ions to  $\text{Fe}^{2+}$  ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymeriza-

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

tion or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists'

preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher  $\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentanal and mome inositol. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content,



antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

The authors confirm contribution to the paper as follows: study conception and design, literature search, methodologies of the lab analyses design: Widyawati PS, Suseno TIP; Fieldwork implementation, data collection, analysis and interpretation of results: Widyawati PS, Ivana F, Natania E; draft manuscript preparation: Widyawati PS; Manuscript revision: Wangtueai S. All authors reviewed the results and approved the final version of the manuscript.

## Data availability

Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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# Effect of butterfly pea (*Clitoria ternatea*) flower extract on qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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## Abstract

Improvement of wet noodles' qualities, sensory, and functional properties was carried out using a composite flour base with the butterfly pea flower extract added. The composite flour consisted of wheat flour and stink lily flour, and  $\kappa$ -carrageenan at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w) was used with concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two factors, namely the composite flour and the concentration of butterfly pea flower extract, and resulted in 12 treatment combinations (K0T0, K0T15, K0T30, K1T0, K1T15, K1T30, K2T0, K2T15, K2T30, K3T0, K3T15, K3T30). The interaction of the composite flour and butterfly pea flower extract significantly affected the color profile, sensory properties, bioactive compounds, and antioxidant activities of wet noodles. However, each factor also significantly influenced the physical properties of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The use of  $\kappa$ -carrageenan up to 3% (w/w) in the mixture increased moisture content, swelling index, and tensile strength but reduced water activity and cooking loss. K3T30 treatment with composite flour of wheat flour-stink lily flour- $\kappa$ -carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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## Introduction

The use of composite flour in wet noodles has been widely used to increase its functional value and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.<sup>[1]</sup> used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.<sup>[2]</sup> stated that potato starch and tapioca starch in a ratio of 50:50 (% w/w) could increase the functional value of wet noodles. Dhull & Sandhu<sup>[3]</sup> stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.<sup>[4]</sup> utilized the mixed ratio of purple wheat bran to improve the quality of wet noodles and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional value of noodles by increasing biological activity (anti-obesity, anti-hyperglycemic, anti-hyper cholesterol, and antioxidant) and extending gastric emptying time<sup>[5,6]</sup>. Widyawati et al.<sup>[7]</sup> explained that using composite flour consisting of wheat flour, stink lily flour, and  $\kappa$ -carrageenan can improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), and 2,2-diphenyl-1-picrylhydrazyl free radical scavenging activity (DPPH), which influences the effectiveness of bioactive compounds in the composite flour that serve as antioxidant sources of wet noodles. Therefore, other ingredients containing phenolic compounds can be added to increase

composite flour's functional values as a source of antioxidants. Czajkowska-González et al.<sup>[8]</sup> mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.<sup>[7]</sup> added pluchea extract to increase the TPC, TFC, and DPPH of wet noodles, however, this resulted in an unattractive wet noodle color. Therefore, it is necessary to incorporate other ingredients to enhance the wet noodles' color profile and their functional properties, one of which is the butterfly pea flower.

Butterfly pea (*Clitoria ternatea*) is a herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white<sup>[9]</sup>. This flower has phytochemical compounds that are antioxidant sources<sup>[10,11]</sup>, including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides<sup>[12,13]</sup>. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products<sup>[14,15]</sup>, one of them is wet noodles<sup>[16,17]</sup>. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose, and amylopectin, depending on partition coefficients, keto-groups, double bonds (in the side chains), and benzene rings<sup>[18]</sup>. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility<sup>[19]</sup>. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf<sup>[7,20]</sup>, gendarussa leaf (*Justicia gendarussa*

Burm.F.)<sup>[21]</sup>, carrot and beetroot<sup>[22]</sup>, kelakai leaf<sup>[23]</sup> contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.<sup>[17]</sup> utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, DPPH, and ferric reducing antioxidant power (FRAP) than the control samples. This extract also improved the color preference and reduced cooked noodles' cutting force, tensile strength, and extensibility. Until now, the application of water extract of butterfly pea flowers in wet noodles has been commercially produced, but the interactions among phytochemical compounds and ingredients of wet noodles base composite flour (stinky lily flour, wheat flour, and  $\kappa$ -carrageenan) have not been elucidated. Therefore, the current study aimed to determine the effect of composite flour and butterfly pea flower extract on wet noodles' quality, bioactive content, antioxidant activity, and sensory properties.

## Materials and methods

### Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari Garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were sorted, washed, dried under open sunlight, powdered using a blender (Philips HR2116, PT Philips, Netherlands) for 3 min, and sieved using a sieve shaker with 45 mesh size (analytic sieve shaker OASS203, Decent, Qingdao Decent Group, China). The water extract of butterfly pea flower was obtained using a hot water extraction at 95 °C for 3 min based on the modified method of Widyawati et al.<sup>[20]</sup> and Putri et al.<sup>[24]</sup> to obtain three concentrations of butterfly pea extract: 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three-composite flour proportions were prepared by mixing wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and  $\kappa$ -carrageenan (Sigma-Aldrich, St. Louis, MO, USA) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

### Chemicals and reagents

Gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), (+)-catechin, and sodium carbonate were purchased from Sigma-Aldrich (St. Louis, MO, USA). Methanol, aluminum chloride, Folin-Ciocalteu's phenol reagent, chloride acid, acetic acid, sodium acetic, sodium nitric, sodium hydroxide, sodium hydrogen phosphate, sodium dihydrogen phosphate, potassium ferricyanide, chloroacetic acid, and ferric chloride were purchased from Merck (Kenilworth, NJ, USA). Distilled water was purchased from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

### Wet noodle preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al.<sup>[25]</sup>, as shown in Table 1. In brief, the composite flour was sieved with 45 mesh size, weighed, and mixed with butterfly pea flower extract at various concentrations. Salt, water, and fresh whole egg were then added and kneaded to form a dough using a mixer (Oxone Master Series 600 Standing Mixer OX 851, China) until the dough obtained was smooth. The dough was sheeted to get noodles about 0.15 cm thick and cut using rollers equipped with cutting blades (Oxone OX355AT, China) to obtain noodles about 0.1 cm wide. Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before being heated in

**Table 1.** Formula of wet noodles.

Treatment	Code	Ingredients				
		Salt (g)	Fresh whole egg (g)	Water (mL)	Butterfly pea extract solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150
9	K2T30	3	30	0	30	150
10	K3T0	3	30	30	0	150
11	K3T15	3	30	0	30	150
12	K3T30	3	30	0	30	150

K0 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour :  $\kappa$ -carrageenan = 80:17:3 (%w/w). T0 = concentration of the butterfly pea extract = 0%. T15 = concentration of the butterfly pea extract = 15%. T30 = concentration of the butterfly pea extract = 30%.

boiled water (100 °C) with a ratio of raw noodles : water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil (Sania, PT Wilmar Nabati, Indonesia) (5% w/w) before being subjected to quality and sensory properties measurements, whereas uncooked noodles without oil coating were used to analyze bioactive compounds and antioxidant activity.

### Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.<sup>[7]</sup>. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 °C for 2 h. The dried noodles were ground using a chopper (Dry Mill Chopper Philips set HR 2116, PT Philips, Netherlands). About 20 g of sample was mixed with 50 mL of solvent mixture (1:1 v/v of methanol/water), stirred at 90 rpm in a shaking water bath at 35 °C for 1 h, and centrifuged at 5,000 rpm for 5 min to obtain supernatant. The obtained residue was re-extracted in an extraction time for three intervals. The supernatant was collected and separated from the residue and then evaporated using a rotary evaporator (Buchi-rotary evaporator R-210, Germany) at 70 rpm, 70 °C, and 200 mbar to generate a concentrated wet noodle extract. The obtained extract was used for further analysis.

### Moisture content analysis

The water content of cooked wet noodles was analyzed using the thermogravimetric method<sup>[26]</sup>. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105–110 °C for 1 h. The processes were followed by weighing the sample and measuring moisture content after obtaining a constant sample weight. The moisture content was calculated based on the difference of initial and obtained constant sample weight divided by the initial sample weight, expressed as a percentage of wet base.

### Water activity analysis

The water activity of cooked wet noodles was analyzed using an  $A_w$ -meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of the sample were weighed, put into an  $A_w$  meter chamber, and analyzed to obtain the sample's water activity<sup>[27]</sup>.

### Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles<sup>[28]</sup>. About 20 cm of the sample was measured for its tensile strength using a texture analyzer equipped with a Texture Exponent Lite Program and a noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to pre-set speed, test speed, and post-test speed at 1, 3, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 s, and 5 g, respectively.

### Color analysis

Ten grams of cooked wet noodles were weighed in a chamber, and the color was analyzed using a color reader (Konica Minolta CR 20, Japan) based on the method of Harijati et al.<sup>[29]</sup>. The parameters measured were lightness ( $L^*$ ), redness ( $a^*$ ), yellowness ( $b^*$ ), hue ( $^{\circ}h$ ), and chroma (C).  $L^*$  value ranged from 0-100 expresses brightness, and  $a^*$  value shows red color with an interval between -80 and +100.  $b^*$  value represents a yellow color with an interval of -70 to +70<sup>[30]</sup>. C indicates the color intensity and  $^{\circ}h$  states the color of samples<sup>[31]</sup>.

### Swelling index analysis

The swelling index was determined using a modified method of Islamiya<sup>[32]</sup>. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. The swelling index was measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles<sup>[33]</sup>. The swelling index was measured from the difference in noodle weights before and after boiling.

### Cooking loss analysis

The cooking loss of the raw wet noodles was analyzed using a modified method of Aditia et al.<sup>[34]</sup>. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick<sup>[35]</sup>. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 °C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 °C until the weight of the sample was constant.

### Total phenolic content analysis

The total phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method by Ayele et al.<sup>[36]</sup>. About 50  $\mu$ L of the extract was added with 1 mL of 10% Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, homogenized, and incubated for 5 min. Then, 2 mL of 7.5%  $\text{Na}_2\text{CO}_3$  was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at  $\lambda_{760}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference used was gallic acid ( $y = 0.0004x + 0.0287$ ,  $R^2 = 0.9877$ ), and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. TPC of samples (mg GAE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TPC (mg GAE/kg dried noodles)} \\ &= \frac{A_s - 0.0287}{0.0004} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ &\quad \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where,  $A_s$  = absorbance of the samples, and  $x$  = weight of the dried noodles.

### Total flavonoid content analysis

Total flavonoid content was analyzed using the modified method of Li et al.<sup>[37]</sup>. The procedure began with mixing 0.3 mL of 5%  $\text{NaNO}_2$  and 250  $\mu$ L of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10%  $\text{AlCl}_3$  was added to the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with distilled water. The sample was homogenized before analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at  $\lambda_{510}$  nm. The result was determined using a (+)-catechin standard reference ( $y = 0.0008x + 0.0014$ ,  $R^2 = 0.9999$ ) and expressed as mg CE (Catechin Equivalent) per kg of dried noodles. TFC of samples (mg CE/kg dried noodles) was calculated using the equation:

$$\begin{aligned} \text{TFC (mg CE/kg dried noodles)} \\ &= \frac{A_s - 0.0014}{0.0008} \times \frac{2 \text{ mL}}{x \text{ g}} \times \\ &\quad \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where,  $A_s$  = absorbance of the samples, and  $x$  = weight of the dried noodles.

### Total anthocyanin content analysis

Total anthocyanin content was determined using the method of Giusti & Wrolstad<sup>[38]</sup>. About 250  $\mu$ L of the sample was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. Then, each sample was mixed and incubated for 15 min and measured at  $\lambda_{543}$  and  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula:  $A = (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}1.0} - (A_{\lambda_{543}} - A_{\lambda_{700}})_{\text{pH}4.5}$ . The total anthocyanin monomer content (TA) ( $\text{mg}\cdot\text{mL}^{-1}$ ) was calculated with the formula:  $\frac{A \times \text{MW} \times \text{DF} \times 1000}{\epsilon \times l}$ , where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2  $\text{g}\cdot\text{mol}^{-1}$ ), DF was the factor of sample dilution, and  $\epsilon$  was the absorptivity molar of delphinidin-3-glucoside (29,000  $\text{L}\cdot\text{cm}^{-1}\cdot\text{mol}^{-1}$ ).

$$\begin{aligned} \text{TA monomer (mg delphinidine-3-glucoside/kg dried noodles)} \\ &= \text{TA (mg/L)} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1,000 \text{ mL}} \times \frac{1,000 \text{ g}}{1 \text{ kg}} \end{aligned}$$

where,  $x$  = the weight of dried noodles.

### 2,2-Diphenyl-1-picrylhydrazyl free radical scavenging activity

DPPH analysis was measured based on the methods of Shirazi et al.<sup>[39]</sup> and Widyawati et al.<sup>[40]</sup>. Briefly, 10  $\mu$ L of the extract was added to a 10 mL test tube containing 3 mL of DPPH solution (4 mg DPPH in 100 mL methanol) and incubated for 15 min in a dark room. The solution was centrifuged at 5,000 rpm for 5 min, and the absorbance of samples was measured at  $\lambda_{517}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The antioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference ( $y = 0.1405x + 2.4741$ ,  $R^2 = 0.9974$ ) and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The percentage of DPPH free radical scavenging activity was calculated using the equation:

Inhibition of DPPH free radical scavenging activity

$$y (\%) = \frac{A_0 - A_s}{A_0} \times 100\%$$

where,  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

DPPH free radical scavenging activity (mg GAE/kg dried noodles) =

$$\frac{y - 2.4741}{0.1405} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where,  $x$  = the weight of dried noodles.

### Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary<sup>[41]</sup>. Approximately 50  $\mu\text{L}$  of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at pH 6.6 and 2.5 mL of 1% potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation, the solution was added with 2.5 mL of 10% mono-chloroacetic acid and shaken until homogenized. Then, 2.5 mL of the supernatant was taken and added with 2.5 mL of bi-distilled water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at  $\lambda_{700}$  nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Gallic acid was used as the standard reference ( $y = 2.2025x - 0.0144$ ,  $R^2 = 0.9983$ ), and the results were expressed in mg GAE (Gallic Acid Equivalent) per kg of dried noodles. The reducing power of samples was calculated using the formula:

$$\text{The reducing power (RP) (\%)} = [(A_s - A_0)/A_s] \times 100\%$$

Where,  $A_0$  = absorbance of the control and  $A_s$  = absorbance of the samples.

$$\text{FRAP (mg GAE/kg dried noodles)} =$$

$$\frac{\text{RP} + 0.0144}{2.2025} \times \frac{2 \text{ mL}}{x \text{ g}} \times \frac{1 \text{ L}}{1000 \text{ mL}} \times \frac{1000 \text{ g}}{1 \text{ kg}}$$

where,  $x$  = the weight of dried noodles.

### Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on the methods of Nugroho et al.<sup>[42]</sup> with modifications. The assessment used hedonic scale scoring with the parameters including color, aroma, taste, and texture attributes with 15 level, score 1 was stated as very much dislike, and 15 was very much like. This sensory analysis was performed by 100 untrained panelists between 17 and 25 years old who had previously gained knowledge of the measurement procedure. Each panelist was presented with 12 samples to be tested and given a questionnaire containing testing instructions and asked to give a score to each sample according to their level of liking. The hedonic scale used is a value of 1–15 given by panelists according to their level of liking for the product. A score of 1–3 indicates very much dislike, a score of 4–6 does not like, a score of 7–9 is neutral, a score of 10–12 likes it, and a score of 13–15 is very much like it. The best treatment was determined by the index effectiveness test<sup>[43]</sup>. The best determination was based on sensory assay which included preferences for color, aroma, taste, and texture. The principle of testing was to give a weight of 0–1 on each parameter based on the level of importance of each parameter. The higher the weight value given means the parameter was increasingly prioritized. The treatment that has the highest value was determined as the best treatment. Procedure to determine the best treatment for wet noodles included:

(a) Calculation of the average of the weight parameters based on the results filled in by panelists

(b) Calculation of normal weight (BN)

$$\text{BN} = \text{Variable weight/Total weight}$$

(c) Calculation of effectiveness value (NE)

NE = Treatment value – worst value/Best value – worst value

(d) Calculation of yield value (NH)

NH = NE  $\times$  normal weight

(d) Calculation of the total productivity value of all parameters

Total NH = NH of color + NH of texture + NH of taste + NH of aroma

(e) Determining the best treatment by choosing the appropriate treatment had the largest total NH

### Design of experiment and statistical analysis

The design of the experiment used was a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour, and  $\kappa$ -carrageenan) including 80:20:0 (K0); 80:19:1 (K1); 80:18:2 (K2), and 80:17:3 (K3) (% w/w), and the three-butterfly pea flower powder extracts, including 0 (T0), 15 (T1), 30 (T3) (% w/v). The experiment was performed in triplicate. The homogenous triplicate data were expressed as the mean  $\pm$  SD. One-way analysis of variance (ANOVA) was carried out, and Duncan's New multiple range test (DMRT) was used to determine the differences between means ( $p \leq 0.05$ ) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

## Results and discussions

### Quality of wet noodles

The quality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, are shown in Tables 2–5, and Fig. 1. Moisture content and water activity ( $A_w$ ) of raw wet noodles were only significantly influenced by the various ratios of composite flour ( $p \leq 0.05$ ) (Table 3). However, the interaction of the two factors, the ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself did not give any significant effects on the water content and  $A_w$  of wet noodles ( $p \leq 0.05$ ) (Table 2). The K3 sample had the highest water content (70% wet base) compared to K0 (68% wet base), K1 (68% wet base), and K2 (69% wet base) because the sample had the highest ratio of  $\kappa$ -carrageenan. An increase of  $\kappa$ -carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also increased the water content of the wet noodles. Water content resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space<sup>[7,20]</sup>. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules<sup>[44]</sup>. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of the gluten network to stabilize it, increasing water binding capacity and retarding the migration of water molecules<sup>[45]</sup>.  $\kappa$ -carrageenan can bind water molecules around 25–40 times<sup>[46]</sup>.  $\kappa$ -carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding<sup>[47]</sup>. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and  $\kappa$ -carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, and intra- and inter-molecular disulfide bonds that can establish water mobility in the dough of the wet noodles. The interaction of all components in the



**Table 2.** Quality properties of wet noodles at various ratios of composite flour and concentrations of butterfly pea flower extract.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0T0	67.94 ± 0.11	0.975 ± 0.008	126.39 ± 2.06	18.91 ± 0.03	0.102 ± 0.008
K0T15	68.31 ± 0.07	0.976 ± 0.005	126.84 ± 1.69	19.02 ± 0.10	0.094 ± 0.003
K0T30	67.86 ± 0.66	0.978 ± 0.008	131.85 ± 2.97	19.76 ± 0.75	0.095 ± 0.003
K1T0	67.64 ± 0.27	0.971 ± 0.009	127.45 ± 7.15	18.71 ± 0.13	0.108 ± 0.007
K1T15	68.34 ± 0.44	0.973 ± 0.004	131.46 ± 0.93	18.77 ± 0.11	0.116 ± 0.011
K1T30	68.63 ± 1.08	0.969 ± 0.005	141.83 ± 8.15	19.32 ± 0.29	0.108 ± 0.008
K2T0	68.64 ± 0.52	0.974 ± 0.008	132.81 ± 3.77	18.26 ± 0.12	0.140 ± 0.002
K2T15	69.57 ± 0.59	0.973 ± 0.004	138.12 ± 1.18	18.43 ± 0.06	0.138 ± 0.006
K2T30	68.46 ± 0.68	0.962 ± 0.002	141.92 ± 8.23	18.76 ± 0.06	0.138 ± 0.013
K3T0	69.71 ± 0.95	0.969 ± 0.008	155.00 ± 4.16	17.54 ± 0.27	0.183 ± 0.002
K3T15	69.08 ± 0.38	0.973 ± 0.005	158.67 ± 7.28	18.03 ± 0.28	0.170 ± 0.011
K3T30	69.76 ± 0.80	0.970 ± 0.005	163.66 ± 7.52	18.33 ± 0.03	0.161 ± 0.002

No significant effect of interaction between composite flour and butterfly pea extract on quality properties of wet noodles. The results were presented as SD of means that were achieved in triplicate. All of the data showed that no interaction of the two parameters influenced the quality properties of wet noodles at  $p \leq 0.05$ .

**Table 3.** Effect of composite flour proportions on quality properties of wet noodles.

Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
K0	68.04 ± 0.40 <sup>a</sup>	0.976 ± 0.01 <sup>b</sup>	128.36 ± 3.30 <sup>a</sup>	19.23 ± 0.55 <sup>d</sup>	0.097 ± 0.097 <sup>a</sup>
K1	68.20 ± 0.74 <sup>a</sup>	0.971 ± 0.01 <sup>a</sup>	133.58 ± 8.42 <sup>b</sup>	18.93 ± 0.34 <sup>c</sup>	0.112 ± 0.111 <sup>b</sup>
K2	68.89 ± 0.73 <sup>b</sup>	0.970 ± 0.01 <sup>a</sup>	137.62 ± 6.05 <sup>b</sup>	18.48 ± 0.23 <sup>b</sup>	0.141 ± 0.139 <sup>c</sup>
K3	69.52 ± 0.73 <sup>c</sup>	0.971 ± 0.01 <sup>a</sup>	159.11 ± 6.77 <sup>c</sup>	17.96 ± 0.40 <sup>a</sup>	0.173 ± 0.171 <sup>d</sup>

All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 4.** Effect of butterfly pea extract concentration on quality properties of wet noodles.

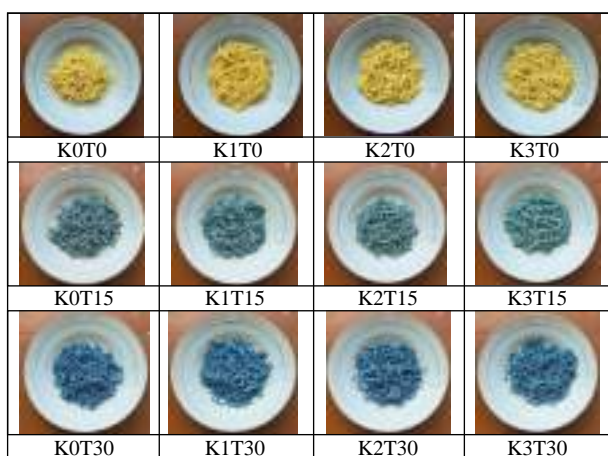
Samples	Moisture content (% w/w)	Water activity	Swelling index (%)	Cooking loss (%)	Tensile strength (g)
T0	68.48 ± 0.96	0.970 ± 0.010	135.41 ± 12.72 <sup>a</sup>	18.35 ± 0.57 <sup>a</sup>	0.134 ± 0.034 <sup>b</sup>
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12 <sup>a</sup>	18.56 ± 0.41 <sup>a</sup>	0.130 ± 0.030 <sup>ab</sup>
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55 <sup>b</sup>	19.04 ± 0.67 <sup>b</sup>	0.129 ± 0.028 <sup>a</sup>

All of the data showed that there was a significant effect of butterfly pea extract concentration on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

composite flour significantly influenced the amount of free water ( $p \leq 0.05$ ) (Table 3). The addition of  $\kappa$ -carrageenan between 1%–3% in the wet noodle formulation reduced the  $A_w$  by about 0.005–0.006. The capability of  $\kappa$ -carrageenan to absorb water molecules reduces the water mobility in the wet noodles due to the involvement of hydroxyl, carbonyl, and

ester sulfate groups of them to form complex structures<sup>[48]</sup>. The complexity of the reaction among components in the wet noodles to form a three-dimensional network influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components between wet noodles and water molecules also contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles were significantly influenced by each factor of the ratios of composite flour or the concentrations of butterfly pea flower extract ( $p \leq 0.05$ ) (Tables 3 & 4). However, the interaction between the two factors was not seen to influence the tensile strength, swelling index, and cooking loss of wet noodles ( $p \leq 0.05$ ) (Table 2). An increase in the ratio of  $\kappa$ -carrageenan in the composite flour increased the tensile strength and swelling index and decreased the cooking loss of wet noodles. On the other hand, the increasing butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. Different ratios of the composite flour affected the tensile strength, which ranged between 0.197 and 0.171 g. At the same time, incorporating butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) to significantly decrease from around 0.003 to 0.008 than control (K1). The highest and lowest swelling index

**Fig. 1** Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

values were owned by K3 and K0 samples, respectively. The swelling index values of wet noodles ranged from 128% to 159%. The effect of the composite flour proportion of wet noodles showed that the K0 sample had the highest cooking loss, and the K3 sample possessed the lowest cooking loss. In contrast, the effect of the concentrations of butterfly pea extract resulted in the lowest cooking loss values of the T0 sample and the highest cooking loss values of the T30 sample. The cooking loss values of wet noodles ranged from 18% to 19%.

Tensile strength, cooking loss, and swelling index of wet noodles were significantly influenced by the interaction of components in dough formation, namely glutenin, gliadin, glucomannan,  $\kappa$ -carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistant to breakage and gel formation.  $\kappa$ -carrageenan is a high molecular weight hydrophilic polysaccharide composed of a hydrophobic 3,6-anhydrous-D-galactose group and hydrophilic sulfate ester group linked by  $\alpha$ -(1,3) and  $\beta$ -(1,4) glycosidic linkages<sup>[49]</sup> that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the  $\beta$ -1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times<sup>[50]</sup> to form a strong gel that increases the viscosity and swelling index of the dough<sup>[51]</sup>. Park & Baik<sup>[52]</sup> stated that the gluten network formation affects the tensile strength of noodles. Huang et al.<sup>[48]</sup> also reported that  $\kappa$ -carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.<sup>[45]</sup> claimed that konjac glucomannan not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable three-dimensional networking structure, thus maintaining dough's rheological and tensile properties.

The increased swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size<sup>[53]</sup>. The synergistic interaction between these hydrocolloids and gluten protein results in a stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices<sup>[54]</sup>. The cross-linking and polymerization involving functional groups of gluten protein,  $\kappa$ -carrageenan, and glucomannan determined binding forces with each other.

The stronger attraction between molecules composed of cross-linking reduces the particles or molecules' loss during cooking<sup>[54,55]</sup>. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan,  $\kappa$ -carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.<sup>[19]</sup> & Widyawati et al.<sup>[7]</sup> explained that phenolic compounds can disturb the interaction between the protein of wheat flour (glutelin and gliadin) and carbohydrate (amylose) to form a complex structure through many interactions, including hydrophobic, electrostatic, and Van der Waals interactions, hydrogen bonding, and  $\pi$ - $\pi$  stacking. The phenolic compounds of butterfly pea extract interacted with  $\kappa$ -carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein,  $\kappa$ -carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals<sup>[55]</sup>. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencing gel formation through aggregation formation and disulfide bridge breakdown<sup>[19,20,56]</sup>.

The color of wet noodles (Table 5 & Fig. 1) was significantly influenced by the interaction between the composite flour and butterfly pea extract ( $p \leq 0.05$ ). The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  increased with increasing the composite flour ratio and the concentration of butterfly pea extract. Most of the color parameter values were lower than the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas an increased amount of butterfly pea extract changed all color parameters. The  $L^*$ ,  $a^*$ ,  $b^*$ ,  $C$ , and  $^{\circ}h$  ranges were about 44 to 67, -13 to 1, -7 to 17, 10 to 16, and 86 to 211, respectively. Lightness, redness, and yellowness of wet noodles intensified with a higher  $\kappa$ -carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing  $\kappa$ -carrageenan proportion from T0 until T15 and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments ( $p \leq 0.05$ ). The presence of  $\kappa$ -carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color.  $\kappa$ -carrageenan was

**Table 5.** Effect of interaction between composite flour and butterfly pea extract on wet noodle color.

Samples	$L^*$	$a^*$	$b^*$	$C$	$^{\circ}h$
K0T0	66.10 $\pm$ 0.30 <sup>f</sup>	0.90 $\pm$ 0.10 <sup>f</sup>	15.70 $\pm$ 0.10 <sup>f</sup>	15.70 $\pm$ 0.10 <sup>f</sup>	86.60 $\pm$ 0.20 <sup>a</sup>
K0T15	48.70 $\pm$ 0.20 <sup>c</sup>	-11.40 $\pm$ 0.30 <sup>bc</sup>	-3.50 $\pm$ 0.20 <sup>c</sup>	12.00 $\pm$ 0.30 <sup>c</sup>	197.00 $\pm$ 0.70 <sup>c</sup>
K0T30	44.00 $\pm$ 0.60 <sup>a</sup>	-12.80 $\pm$ 0.20 <sup>a</sup>	-6.50 $\pm$ 0.30 <sup>a</sup>	14.40 $\pm$ 0.20 <sup>e</sup>	206.90 $\pm$ 1.00 <sup>d</sup>
K1T0	67.10 $\pm$ 0.40 <sup>f</sup>	0.90 $\pm$ 0.20 <sup>f</sup>	15.80 $\pm$ 0.60 <sup>f</sup>	15.80 $\pm$ 0.60 <sup>f</sup>	86.60 $\pm$ 0.50 <sup>a</sup>
K1T15	51.50 $\pm$ 1.80 <sup>d</sup>	-10.80 $\pm$ 0.40 <sup>cd</sup>	-3.00 $\pm$ 0.20 <sup>cd</sup>	11.30 $\pm$ 0.40 <sup>bc</sup>	195.60 $\pm$ 0.60 <sup>c</sup>
K1T30	45.50 $\pm$ 0.20 <sup>b</sup>	-11.80 $\pm$ 0.80 <sup>b</sup>	-6.30 $\pm$ 0.30 <sup>a</sup>	13.40 $\pm$ 0.70 <sup>d</sup>	208.40 $\pm$ 2.30 <sup>d</sup>
K2T0	67.10 $\pm$ 0.20 <sup>f</sup>	1.00 $\pm$ 0.10 <sup>f</sup>	16.30 $\pm$ 0.10 <sup>g</sup>	16.30 $\pm$ 0.10 <sup>g</sup>	86.40 $\pm$ 0.10 <sup>a</sup>
K2T15	53.40 $\pm$ 0.30 <sup>e</sup>	-10.30 $\pm$ 0.80 <sup>de</sup>	-2.80 $\pm$ 0.10 <sup>d</sup>	10.70 $\pm$ 0.80 <sup>b</sup>	195.50 $\pm$ 1.30 <sup>c</sup>
K2T30	46.00 $\pm$ 0.40 <sup>b</sup>	-10.40 $\pm$ 0.20 <sup>de</sup>	-6.10 $\pm$ 0.40 <sup>a</sup>	12.10 $\pm$ 0.40 <sup>c</sup>	210.60 $\pm$ 1.30 <sup>e</sup>
K3T0	67.40 $\pm$ 0.30 <sup>f</sup>	1.20 $\pm$ 0.10 <sup>f</sup>	16.80 $\pm$ 0.70 <sup>g</sup>	16.90 $\pm$ 0.70 <sup>g</sup>	85.90 $\pm$ 0.20 <sup>a</sup>
K3T15	53.80 $\pm$ 1.30 <sup>e</sup>	-9.80 $\pm$ 0.70 <sup>e</sup>	-1.20 $\pm$ 0.20 <sup>e</sup>	9.90 $\pm$ 0.70 <sup>a</sup>	187.50 $\pm$ 1.10 <sup>b</sup>
K3T30	47.90 $\pm$ 0.70 <sup>c</sup>	-10.10 $\pm$ 0.40 <sup>de</sup>	-5.50 $\pm$ 0.30 <sup>b</sup>	11.60 $\pm$ 0.20 <sup>bc</sup>	208.40 $\pm$ 2.30 <sup>d</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the quality properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi<sup>[57]</sup> reported that  $\kappa$ -carrageenan can associate polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making a three-dimensional network structure that implicated all components of composite flour was exceptionally complicated due to the involved polar and non-polar functional groups and many kinds of interaction between them. These influenced the water content and water activity of the wet noodles, which impacted the wet noodle color. Another possible cause that affects wet noodles' color profile is anthocyanin pigment from the butterfly pea extract. Vidana Gamage et al.<sup>[58]</sup> reported that the anthocyanin pigment of butterfly pea is delphinidin-3-glucoside and has a blue color. Increasing butterfly pea extract concentration lowered the lightness, redness, yellowness, and chroma and also changed the hue color from yellow to green-blue color.

The effect of composite flour and butterfly pea extract on color was observed in chroma and hue values. Glucomannan proportion of stinky lily flour intensified redness and yellowness, but butterfly pea extract reduced the two parameters. Thanh et al.<sup>[59]</sup> also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and  $\kappa$ -carrageenan, impacting the color change of wet noodles. Thus, the sample T0 was yellow, T15 was green, and T30 was blue. Color intensity showed as chroma values of yellow values increased along with the higher proportion of  $\kappa$ -carrageenan at the same concentration of butterfly pea extract. However, the higher concentration of butterfly pea extract lessened the green and blue colors of wet noodles made using the same proportion of composite flour. Wet

noodle color is also estimated to be influenced by the phenolic compound content, which underwent polymerization or degradation during the heating process. Widyawati et al.<sup>[20]</sup> reported that the bioactive compounds in pluchea extract could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles exhibiting the strongest blue color due to different interactions between anthocyanin and hydrocolloid compounds, especially  $\kappa$ -carrageenan, that could reduce the intensity of blue color or chroma values.

### Phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) content of wet noodles

The results of TPC, TFC, and TAC are shown in Table 6. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: the ratio of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). The highest proportion of  $\kappa$ -carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC of about ~207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. The TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition led to an increase in TAC. The extract addition in T30 possessed a TAC of about  $3.92 \pm 0.18$  mg delphinidin-3-glucoside/kg dried noodles. In addition, based on Pearson correlation assessment, there was a strong, positive correlation between the TPC of wet noodles and the TFC at T0 ( $r = 0.955$ ), T15 ( $r = 0.946$ ), and T30 treatments ( $r = 0.765$ ). In contrast, a weak, positive correlation was observed between the TPC of samples and the TAC at T0 ( $r = 0.153$ ) and T30 treatments ( $r = 0.067$ ), except the T15 treatment, which had a correlation coefficient of  $-0.092$  (Table 7).

**Table 6.** Effect of interaction between composite flour and butterfly pea extract on wet noodle's bioactive compounds and antioxidant activity.

Samples	TPC (mg GAE/kg dried noodles)	TFC (mg CE/kg dried noodles)	TAC (mg define-3-glucoside/kg dried noodles)	DPPH (mg GAE/kg dried noodles)	FRAP (mg GAE/kg dried noodles)
K0T0	126.07 $\pm$ 0.90 <sup>a</sup>	16.74 $\pm$ 6.26 <sup>a</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	2.99 $\pm$ 0.16 <sup>a</sup>	0.009 $\pm$ 0.001 <sup>a</sup>
K0T15	172.57 $\pm$ 2.14 <sup>e</sup>	36.66 $\pm$ 2.84 <sup>d</sup>	2.67 $\pm$ 0.21 <sup>b</sup>	21.54 $\pm$ 1.71 <sup>d</sup>	0.023 $\pm$ 0.002 <sup>c</sup>
K0T30	178.07 $\pm$ 2.54 <sup>f</sup>	48.36 $\pm$ 3.29 <sup>f</sup>	3.94 $\pm$ 0.28 <sup>c</sup>	39.23 $\pm$ 0.91 <sup>f</sup>	0.027 $\pm$ 0.002 <sup>e</sup>
K1T0	137.07 $\pm$ 1.32 <sup>b</sup>	21.66 $\pm$ 3.67 <sup>b</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	3.13 $\pm$ 0.19 <sup>a</sup>	0.011 $\pm$ 0.001 <sup>a</sup>
K1T15	178.48 $\pm$ 0.95 <sup>f</sup>	36.95 $\pm$ 3.05 <sup>d</sup>	2.74 $\pm$ 0.21 <sup>b</sup>	21.94 $\pm$ 0.68 <sup>d</sup>	0.023 $\pm$ 0.001 <sup>cd</sup>
K1T30	183.65 $\pm$ 1.67 <sup>g</sup>	52.28 $\pm$ 3.08 <sup>g</sup>	3.84 $\pm$ 0.19 <sup>c</sup>	41.42 $\pm$ 1.30 <sup>g</sup>	0.029 $\pm$ 0.001 <sup>f</sup>
K2T0	150.40 $\pm$ 0.52 <sup>d</sup>	27.49 $\pm$ 5.39 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	7.45 $\pm$ 0.69 <sup>c</sup>	0.014 $\pm$ 0.001 <sup>b</sup>
K2T15	202.48 $\pm$ 0.63 <sup>j</sup>	48.28 $\pm$ 2.41 <sup>f</sup>	2.95 $\pm$ 0.57 <sup>b</sup>	24.70 $\pm$ 0.90 <sup>e</sup>	0.025 $\pm$ 0.001 <sup>d</sup>
K2T30	206.90 $\pm$ 2.43 <sup>i</sup>	56.99 $\pm$ 7.45 <sup>h</sup>	3.93 $\pm$ 0.42 <sup>c</sup>	47.55 $\pm$ 1.31 <sup>i</sup>	0.034 $\pm$ 0.002 <sup>g</sup>
K3T0	141.15 $\pm$ 1.28 <sup>c</sup>	25.37 $\pm$ 3.46 <sup>c</sup>	0.00 $\pm$ 0.00 <sup>a</sup>	5.45 $\pm$ 0.49 <sup>b</sup>	0.013 $\pm$ 0.001 <sup>b</sup>
K3T15	186.32 $\pm$ 1.15 <sup>h</sup>	43.57 $\pm$ 2.28 <sup>e</sup>	2.66 $\pm$ 0.21 <sup>b</sup>	22.45 $\pm$ 0.48 <sup>d</sup>	0.024 $\pm$ 0.001 <sup>cd</sup>
K3T30	189.90 $\pm$ 0.63 <sup>k</sup>	54.95 $\pm$ 3.72 <sup>gh</sup>	3.98 $\pm$ 0.37 <sup>c</sup>	44.93 $\pm$ 1.28 <sup>h</sup>	0.031 $\pm$ 0.001 <sup>f</sup>

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract to bioactive compounds and antioxidant activity of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

**Table 7.** Pearson correlation coefficients between bioactive contents (TPC, TFC, and TAC) and antioxidant activity (DPPH and FRAP).

Parameter	TPC			TFC			TAC			DPPH		
	T0	T15	T30	T0	T15	T30	T0	T15	T30	T0	T15	T30
TPC	1	1	1									
TFC	0.955	0.946	0.765	1	1	1						
TAC	0.153	-0.092	0.067	0.028	-0.239	-0.020	1	1	1			
DPPH	0.893	0.815	0.883	0.883	0.739	0.753	0.123	0.127	0.194	1	1	1
FRAP	0.884	0.425	0.859	0.902	0.464	0.742	0.056	-0.122	-0.131	0.881	0.321	0.847

Correlation significant at the 0.05 level (2-tailed).



The bioactive compounds of wet noodles were correlated with their quality properties and antioxidant activity (AOA). The dominant anthocyanin pigment from butterfly pea extract is delphinidin<sup>[60]</sup>, around 2.41 mg/g samples<sup>[61]</sup> that has more free acyl groups and aglycone structure<sup>[62]</sup> that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling<sup>[63]</sup>. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol,  $\beta$ -sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylstragalgin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)<sup>[12,13]</sup>, chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids<sup>[62]</sup>, ternatin anthocyanins, fatty acids, tocopherols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylidene), and hirsutene<sup>[64]</sup>, that contribute to the antioxidant activity<sup>[10,64]</sup>. *Clitoria ternatea* exhibits antioxidant activity based on the antioxidant assays, such as 2,2-diphenyl-1-picrylhydrazyl radical (DPPH) radical scavenging, ferric reducing antioxidant power (FRAP), hydroxyl radical scavenging activity (HRSA), hydrogen peroxide scavenging, oxygen radical absorbance capacity (ORAC), superoxide radical scavenging activity (SRSA), ferrous ion chelating power, 2,2'-azino-bis(3-ethylbenzthiazoline-6-sulphonic acid) (ABTS) radical scavenging, and Cu<sup>2+</sup> reducing power assays<sup>[64]</sup>. The TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in the composite flour and the higher concentration of butterfly pea extract. Zhou et al.<sup>[65]</sup> claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteu's phenol reagent. Devaraj et al.<sup>[66]</sup> reported that 3,5-acetylalbulin is a flavonoid compound in glucomannan that can form a complex with AlCl<sub>3</sub>.

### Antioxidant activity of wet noodles

The antioxidant activity (AOA) of wet noodles was determined using DPPH radical scavenging activity (DPPH) and ferric reducing antioxidant power (FRAP), as shown in Table 6. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ( $p \leq 0.05$ ). The noodles exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. Several wet noodle samples, including the composite flour of K0 and K1 and without butterfly pea extracts (K0T0 and K1T0), had the lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had the highest DPPH. Pearson correlation showed that the TPC and TFC were strongly and positively correlated with the DPPH (Table 7). The correlated coefficient values ( $r$ ) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. Meanwhile, the  $r$  values between TFC and DPPH at T0, T15, and T30 treatments were 0.883, 0.739, and 0.753, respectively. However, the correlation coefficient values between TAC and AOA at T0, T15, and T30 treatments were 0.123, 0.127, and 0.194, respectively. The interaction among glucomannan, phenolic compounds, amylose, gliadin, and glutelin in the dough of wet noodles determined the number and position of free hydroxyl groups

that influenced the TPC, TFC, and DPPH. Widyawati et al.<sup>[40]</sup> stated that free radical inhibition activity and chelating agent of phenolic compounds depends on the position of hydroxyl groups and the conjugated double bond of phenolic structures. The values of TPC, TFC, and DPPH significantly increased with higher levels of stinky lily flour and  $\kappa$ -carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and  $\kappa$ -carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and  $\kappa$ -carrageenan with a ratio of 17%:3% (w/w) was able to reduce free hydroxyl groups, which had the potential as electron or hydrogen donors in testing TPC, TFC, and DPPH.

FRAP of wet noodles was significantly influenced by the interaction of two parameters of the proportion of composite flour and the concentration of butterfly pea extracts ( $p \leq 0.05$ ). FRAP was used to measure the capability of antioxidant compounds to reduce Fe<sup>3+</sup> ions to Fe<sup>2+</sup> ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without  $\kappa$ -carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30% of butterfly pea extract (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC and TFC at T0 and T30 treatments had strong and positive correlations to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The correlation coefficient ( $r$ ) values of TAC at the 0 treatment was weak with a positive correlation to FRAP samples, but the  $r$  values at T15 and T30 treatments showed weak negative correlations (Table 7). The obtained correlation between DPPH and FRAP activities elucidates that the DPPH method was highly correlated with the FRAP method at the T0 and T30 treatments and weakly correlated at the T15 treatment (Table 7). The DPPH and FRAP methods showed the capability of wet noodles to scavenge free radicals was higher than their ability to reduce ferric ion. It proved that the bioactive compounds of wet noodles have more potential as free radical scavengers or hydrogen donors than as electron donors. Compounds that have reducing power can act as primary and secondary antioxidants<sup>[67]</sup>. Poli et al.<sup>[68]</sup> stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.<sup>[69]</sup> claimed that a secondary antioxidant is a natural antioxidant that can reduce ferric ion (FRAP). Based on AOA assay results, phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as flavonoids are the major phenolic compounds potential as antioxidant agents through their ability to scavenge various free radicals. The effectivity of flavonoid compounds in inhibiting free radicals and chelating agents is influenced by the number and position of hydrogen groups and conjugated diene at A, B, and C rings<sup>[70]</sup>. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals<sup>[71]</sup>. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.<sup>[71]</sup> stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins insignificantly correlate with AOA. Different structure of anthocyanins in samples determines AOA. Moreover, the polymerization or complexation of anthocyanins with other molecules also determines their capability as electron or hydrogen donors.

**Table 8.** Effect of interaction between composite flour and butterfly pea extract to sensory properties of wet noodles and the best treatment of wet noodles based on index effectiveness test.

Samples	Color	Aroma	Taste	Texture	Index effectiveness test
K0T0	8.69 ± 3.31 <sup>a</sup>	7.41 ± 3.80 <sup>a</sup>	8.71 ± 3.16 <sup>a</sup>	10.78 ± 2.86 <sup>abcde</sup>	0.1597
K0T15	8.96 ± 3.38 <sup>b</sup>	7.75 ± 3.89 <sup>b</sup>	9.35 ± 3.36 <sup>cde</sup>	11.19 ± 3.10 <sup>abcd</sup>	0.6219
K0T30	8.93 ± 3.50 <sup>bc</sup>	7.71 ± 3.76 <sup>c</sup>	9.26 ± 3.17 <sup>bcd</sup>	11.13 ± 3.09 <sup>a</sup>	0.6691
K1T0	8.74 ± 3.62 <sup>a</sup>	8.13 ± 3.56 <sup>ab</sup>	9.58 ± 3.13 <sup>ab</sup>	11.33 ± 3.12 <sup>de</sup>	0.4339
K1T15	9.98 ± 3.06 <sup>bc</sup>	8.40 ± 3.28 <sup>c</sup>	10.16 ± 2.59 <sup>def</sup>	10.61 ± 2.82 <sup>ab</sup>	0.7086
K1T30	10.08 ± 3.28 <sup>bc</sup>	9.10 ± 3.08 <sup>c</sup>	10.44 ± 2.32 <sup>bcd</sup>	10.36 ± 2.81 <sup>ab</sup>	0.7389
K2T0	10.41 ± 3.01 <sup>a</sup>	9.39 ± 3.27 <sup>ab</sup>	11.04 ± 2.44 <sup>ab</sup>	10.55 ± 2.60 <sup>cde</sup>	0.3969
K2T15	10.8 ± 2.85 <sup>bc</sup>	9.26 ± 3.10 <sup>c</sup>	10.11 ± 2.76 <sup>f</sup>	10.89 ± 2.65 <sup>abcd</sup>	0.9219
K2T30	10.73 ± 3.02 <sup>c</sup>	9.10 ± 3.46 <sup>c</sup>	9.85 ± 2.99 <sup>def</sup>	10.16 ± 2.74 <sup>abc</sup>	0.9112
K3T0	10.73 ± 3.42 <sup>a</sup>	9.19 ± 3.38 <sup>b</sup>	9.93 ± 2.50 <sup>bc</sup>	10.34 ± 2.84 <sup>e</sup>	0.5249
K3T15	10.91 ± 3.23 <sup>bc</sup>	9.48 ± 3.56 <sup>c</sup>	10.45 ± 2.82 <sup>cde</sup>	10.49 ± 2.68 <sup>bcde</sup>	0.9235
K3T30	10.88 ± 3.14 <sup>c</sup>	9.49 ± 3.59 <sup>c</sup>	10.81 ± 2.74 <sup>ef</sup>	10.86 ± 2.60 <sup>bcde</sup>	1.0504

All of the data showed that there was a significant effect of interaction between composite flour and butterfly pea extract on the sensory properties of wet noodles at  $p \leq 0.05$ . The results were presented as SD of means that were achieved in triplicate. Means with different superscript letters in the same column are significantly different,  $p \leq 0.05$ .

Martin et al.<sup>[72]</sup> informed that anthocyanins are the major groups of phenolic pigments where their antioxidant activity greatly depends on the steric hindrance of their chemical structure, such as the number and position of hydroxyl groups and the conjugated double bonds, as well as the presence of electrons in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positively correlated with FRAP assay due to the role of phenolic compounds as reducing power agents that contributed to donating electrons. Paddayappa et al.<sup>[67]</sup> reported that the phenolic compounds are capable of embroiling redox activities with an action as hydrogen donor and reducing agent. The weak relationship between TPC, TFC, or DPPH, and FRAP in the T15 treatment suggested that there was an interaction between the functional groups in the benzene ring in phenolic and flavonoid compounds and the functional groups in components in composite flour, thereby reducing the ability of phenolic and flavonoid compounds to donate electrons.

### Sensory evaluation

Sensory properties of wet noodles based on the hedonic test results showed that composite flour and butterfly pea extract addition significantly influenced color, aroma, taste, and texture preferences ( $p \leq 0.05$ ) (Table 8). The preference values of color, aroma, taste, and texture attributes of wet noodles ranged from 5 to 6, 6 to 7, 6 to 7, and 5 to 7, respectively. Incorporating butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensities of wet noodle color that resulted in color degradation from yellow, green, to blue color, impacting the color preference of wet noodles. Nugroho et al.<sup>[42]</sup> also reported that the addition of butterfly pea extracts elevated the preference of panelists for dried noodles. The aroma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused the wet noodles to have a stronger, musty smell. Utami et al.<sup>[73]</sup> claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of  $\kappa$ -carrageenan could reduce the proportion of stinky lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri<sup>[74]</sup> noted that panelists preferred noodles substituted with a higher

$\kappa$ -carrageenan. Widyawati et al.<sup>[7]</sup> also proved that  $\kappa$ -carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.<sup>[63]</sup> added that volatile compounds of butterfly pea extract can mask the musty smell of stinky lily flour, such as pentan-3-ol and menthyl acetate. In addition, Padmawati et al.<sup>[75]</sup> revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin<sup>[76]</sup>, due to Maillard reaction during stinky lily flour processing. Nevertheless, using butterfly pea extract at a higher concentration in wet noodles increased the bitter taste, which is contributed by tannin compounds in this flower, as has been found by Handayani & Kumalasari<sup>[77]</sup>. The effect of composite flour proportion and butterfly pea extract addition also appeared to affect the texture preference of wet noodles. Panelists preferred wet noodles that did not break up easily, which was the K3T0 sample, as the treatment resulted in chewy and elastic wet noodles. The results were also affected by the tensile strength of wet noodles because of the different concentrations of butterfly pea extract added to the wet noodles. The addition of butterfly pea extract at a higher concentration resulted in sticky, easy-to-break, and less chewy wet noodles<sup>[18,19,77]</sup> due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan to interact with water molecules to form gel<sup>[78]</sup>. Based on the index effectiveness test, the noodles made with composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment, with a total score of 1.0504.

### Conclusions

Using composite flour containing wheat flour, stinky lily flour, and  $\kappa$ -carrageenan and butterfly pea extract in wet noodle influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan,  $\kappa$ -carrageenan, and phenolic compounds affected the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, swelling index, bioactive content, antioxidant activity, and sensory properties of wet noodles. The higher concentration of hydrocolloid addition caused increased

water content and swelling index and decreased water activity and cooking loss. In addition, incorporating butterfly pea extract improved color, bioactive content, and antioxidant activity and enhanced panelists preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of the resulting wet noodles.

## Author contributions

The authors confirm contribution to the paper as follows: study conception and design, literature search, methodologies of the lab analyses design: Widyawati PS, Suseno TIP; Fieldwork implementation, data collection, analysis and interpretation of results: Widyawati PS, Ivana F, Natania E; draft manuscript preparation: Widyawati PS; Manuscript revision: Wangtueai S. All authors reviewed the results and approved the final version of the manuscript.

## Data availability

Data reported in this study are contained within the article. The underlying raw data are available on request from the corresponding author.

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## Conflict of interest

The authors declare that they have no conflict of interest.

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## Composite flour-butterfly pea flower

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