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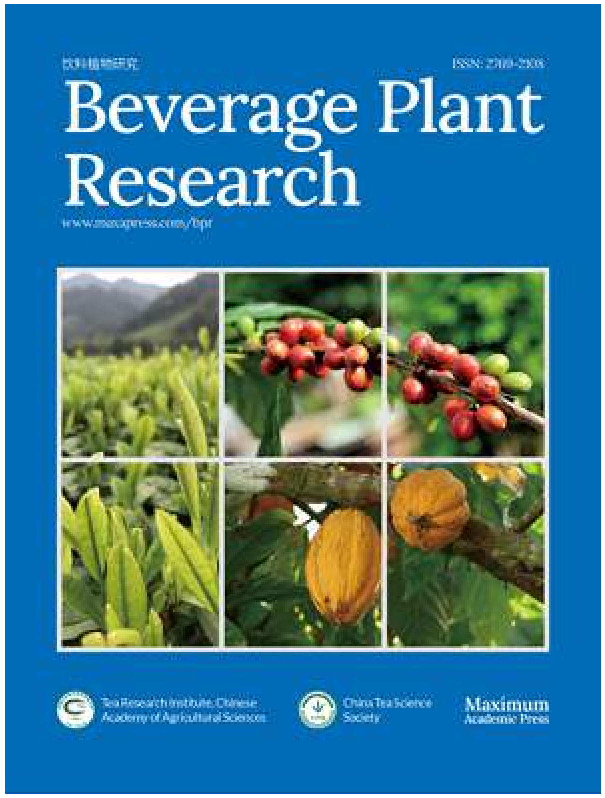

Effect of composite flour proportion and butterfly pea (Clitoria ternatea) flower extract to qualities, sensory properties and antioxidant activity of wet noodles

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

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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Abstract

The improving of wet noodles qualities, sensory and functional properties were done by using the composite flour base added with the butterfly pea flower extract. The composite flour of wheat flour, stink lily flour and κ-carrageenan at various ratio of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentration of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed randomized block design with 2 factors, namely the composite flour and the concentration of butterfly pea flower extract that resulted 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 were significantly affected the color, sensory properties, bioactive compounds, and antioxidant activity of wet noodles. However, each factor had significant influenced of the physical properties from wet noodles, such as moisture content, water activity, tensile strength, swelling index and cooking loss. The using of κ-carrageenan up to 3% (w/w) in composite flour 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-κ-carrageenan at ratio of 80:17:3 (% w/w) was the best consumer acceptance based on hedonic sensory score.

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

Introduction

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

Previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional values of noodles by increasing the biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and prolong gastric emptying time [8,9]. However, adding of stink lily flour in base noodles flour had limited on elasticity and tensile strength of wet noodles [10,11]. Then, the κ-carrageenan was added to improve the texture properties of wet noodles. Those components were a collaborates with glucomannan to form cross linking with glutenin and gliadin by intern and intra-molecular bonds leading to improving of noodle texture [12-14]. Widyawati et al. [15] explained that using of the composite flour consisted of wheat flour, stink lily flour and κ-carrageenan can look up swelling index, total phenolic content (TPC), total flavonoid content (TFC) and DPPH free radical scavenging activity that influences an effectivity of bioactive compounds on composite flour as antioxidant of wet noodles. Therefore, addition of the other ingredient enriched phenolic compounds is done to increase functional values of composite flour as antioxidant. Czajkowska–González et al. [16] informed that elaborate of natural antioxidant sources enriched phenolic compounds can improve functional values of bread. Widyawati et al. [15] has added pluchea extract to increase TPC, TFC and DPPH free radical scavenging activity of wet noodles, but the weakness of wet noodle color is not attractive that it is necessary to look for other ingredients, one of which is butterfly pea flower.

Butterfly pea (*Clitoria ternatea)* is an herb plant, Fabaceae family, having various color flower, such as purple, blue, pink, and white [17]. This flower has phytochemical compounds which are benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides [20,21]. Anthocyanins of the butterfly pea flower has been used as natural color in many food products [22,23], one of them is wet noodles [24,25]. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose and amylopectin depend on partition coefficients, keto-groups, double bonds (in the side chains), and the benzene ring [26]. This interaction involves covalent and non-covalent bonds of them which were influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility [27]. Previous study has proven that the use of phenolic compounds from plant extract, such as pluchea leaf [15,28], gendarussa leaf (*Justicia gendarussa* Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31] establishes the quality, bioactive compounds, antioxidant activity and sensory properties of wet noodles. Shiau et al. [25] has utilized natural color of butterfly pea flower extract to make wet noodles base wheat flour that results the higher total anthocyanin, polyphenol, DPPH scavenging activity and reducing power than the control samples and the use of this extract can improve color preference and reduce the cutting force, tensile strength, and extensibility of cooked noodles. 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 κ-carrageenan) has not been studied. Therefore, the study was conducted to decide the effect of composite flour and butterfly pea flower extract to quality, bioactive content, antioxidant activity, and sensory properties of wet noodles.

Materials and Methods

Raw materials and preparation

Butterfly pea flower was obtained from Penjaringan Sari garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flower was sorted, washed, dried by open sunlight, powdered using blender (Philips HR2116, PT Philips, Netherlands) for 3 min, 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 hot water extraction at 95^{o}C for 3 min to get three concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three composite flours proportion were prepared with a mixing of wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and κ-carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratio of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

Chemical and reagents

The 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). Distillated water was purchased by local market (PT Aqua Surabaya, Surabaya, Indonesia).

Wet noodles preparation

Wet Noodles were prepared based on the modified formula of Panjaitan et al. [11] 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 concentration. The salt, water, fresh whole egg was then added and kneaded to make dough by using a mixer machine (Oxone Master Series 600 Standing Mixer OX 851, China). The dough was sheeted and cut via rollers using cutting blades (Oxone OX355AT, China). Wet noodles were sprinkled with tapioca flour before heated in boiled water (100^{o}C) with a ratio of raw noodles /water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil before subjected to measure the quality and sensory properties but the samples without cooking and oil coating were used to analyze the bioactive compounds and antioxidant activity.

Extraction of bioactive compounds of wet noodles

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

Moisture content analysis

Water content of cooked wet noodles was analyzed based on thermogravimetry method[32]. 1 g samples were weighed in weighing bottle and heated by drying oven at 105-110^{o}C for 1 h, then samples were weighed and measured moisture content after weight of samples was constant. Moisture content is calculated based on the difference in sample weight before and after a constant weight is reached divided by the initial sample weight expressed as a percentage of wet base.

Water activity analysis

Water activity of cooked wet noodles was analyzed using Aw-meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). 10 g samples were weighed and entered in Aw meter chamber, analyzed and data recorded [33].

Tensile strength analysis

Tensile strength is essential parameter that measures extensibility of cooked wet noodles[39]. 20 cm samples were measured tensile strength using texture analyzer that be equipped by Texture Exponent Lite Program and used noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to be pre-set speed, test speed, post-test speed 1 mm/s, 3 mm, 10 mm/s, respectively. Distance, time, and trigger force were used 100 mm, 5 sec and 5 g, respectively.

Color analysis

10 g cooked wet noodles were weighed in chamber and analyzed color using color rider (Konica Minolta CR 20, Japan) based on the method of Harijati et al.[35]. Parameter measurement was lightness ($L*$), redness ($a*$), yellowness ($b*$), Hue (^{o}h), and chroma (C). $L*$ value is ranged 0-100 that expressed brightness, $a*$ value shows red color which has an interval between -80 - +100.

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

Swelling index analysis

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

Cooking loss analysis

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

Total phenolic content analysis

Total phenolic content of wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method of Eyele et al. [42]. 50 µL of extract was added 1 mL of 10% Folin-Ciocalteu's phenol reagent in 10 mL volumetric flask, shaken and incubated for 5 min. Then, 2 mL of 7.5 % Na_2CO_3 was added and the volume was adjusted to 10 mL with distillated water. Solution was measured absorbance at λ 760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference was used gallic acid and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Total flavonoid content analysis

Total flavonoid content was analyzed on the modified method using Li et al. [2013]. 250 µL of noodle extract was added with 0.3 mL of 5% $NaNO_2$ and incubated for 5 min in a 10 mL volumetric flask. After 5 min of incubation, 0.3 mL of 10% $AlCl_3$ was added. After 5 min, 2 mL of 1 M NaOH was added and the volume was adjusted to 10 mL with distillated water. Samples were mixed and homogenized before was analyzed using spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ. 510 nm. The result was determined using (+)-catechin standard reference and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

Total anthocyanin content analysis

Total anthocyanin content was determined on the method of Giustl and Wrolstad [44]. 250 µL samples were added buffer solution at pH 1 and pH 4.5 in 10 mL test tube. And then each of samples was mixed and incubated for 15 min and measured at λ 543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Absorbance (A) of samples was calculated with formula: A $=(A\lambda 543 - A\lambda 700)pH\ 1.0 - (A\lambda 543 - A\lambda 700)pH4.5$. The total anthocyanin content (mg/mL) was calculated by formula: $\frac{AxMWxDFx1000}{\varepsilon x\ l}$. Where A was absorbance, MW was molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was factor of sample dilution, and ε was absorptivity molar of delphinidin-3-glucoside (29000 L cm^{-1} mol^{-1}).

DPPH free radical scavenging activity

DPPH scavenging activity was measured based on method of Shirazi et al. [45] and Widyawati et al.[46]. Briefly, 10 µL 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. Solution was centrifuged at 5000 rpm for 5 min and absorbance of samples was measured at λ. 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant activity of samples was stated as inhibition capacity with gallic acid as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Ferric reducing antioxidant power

FRAP analysis was used the modified method of Al-Temimi and Choundhary [47]. 50 µL of extract in a test tube was added 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^{o}C. After incubation 20 min, solution was added 2.5 ml of 10% mono chloroacetic acid and shaken. Then, 2.5 mL of supernatant was taken and added 2.5 mL of bi-distillated water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured absorbance at λ=700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant capacity was used gallic acid as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Sensory evaluation

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

Design of experiment and statistical analysis

Design of experiment used a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour and κ-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 done in three replications. The homogenous data of triplicate analysis was expressed as the mean ± SD. The one-way analysis of variance (ANOVA) was done and Duncan's New multiple range test (DMRT) was used to determine for 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

Quality of wet noodles including moisture content, water activity, tensile strength, swelling index, cooking loss, and color was shown in Table 2 and Fig.1, 2, 3, and 4. Moisture content and water activity (AW) of raw wet noodles were only significantly influenced the various ratio of composite flour ($p \leq 0.05$) (Fig. 1). However, the interaction of two factors, the difference in the ratio of composite flour and the concentration of butterfly pea extract or the concentration of butterfly pea extract itself, did not have a significant effect on the water content and AW 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 samples had the highest ratio of κ-carrageenan. The increasing of κ-carrageenan proportion influenced the amount of free and bound water in the wet noodle samples that increased the water content of wet noodles. Water content measures the amount of free and weakly bound water in the pores, intermolecular, and intercellular space of samples [15,28,49]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecule [50]. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of gluten network to stability gluten network that increases water binding capacity and retards the migration of water molecules[51,52]. κ-carrageenan can bind water molecule around 25-40 times [53]. The κ-carrageenan can cause the structure change of gluten protein though electrostatic interactions and hydrogen bonding [54,55]. Interaction among protein of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour and κ-carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, intra-and inter-molecular disulfide bonds that is be able to establish water mobility in dough of this wet noodles. The effect of this interaction of all components of composite flour significantly influenced of the amount of free water ($p \leq 0.05$) (Fig. 1). The addition of κ-carrageenan between 1-3% in the wet noodle formulation reduced the AW about 0.005-0.006. The capability of κ-carrageenan absorbed water molecules reduces the water mobility in wet noodles due to the involving of hydroxyl, carbonyl, and ester sulphate groups of them to form complex structure [55-57]. The complexity of the reaction among components in wet noodles to form a three-dimensional networking influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components arranged of wet noodles and water molecules also specified the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles was significant influenced by each factors of the composite flour or the concentration of butterfly pea flower extract ($p \leq 0.05$) (Fig. 1 and 2), but the interaction of the various ratio of composite flour and the concentration of butterfly pea extract was not significant influenced the tensile strength, swelling index, and cooking loss of wet noodles ($p \leq . 0.05$) (Table 2). The increasing of the ratio of κ-carrageenan in composite flour increased the tensile strength and swelling index, and decreased cooking loss of wet noodles, but the increasing of the concentration of butterfly pea extract decreased the tensile strength and increased swelling index and cooking loss of wet noodles. The effect of the ratio of composite flour to the tensile strength ranged between 0.197 to 0.171 g. While the addition of butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) significant lower around 0.003 until 0.008 than control (K1). The highest swelling index values was owned by K3 sample and the lowest swelling index values were belonging of the K0 sample. The swelling index values of wet noodles ranged around 128 to 159 %. The effect of composite flour proportion of wet noodles showed that K0 sample had the highest cooking loss and K3 sample possessed the lowest cooking loss. While the effect of the concentration of butterfly pea extract resulted the lowest cooking loss values of T0 sample and the highest cooking loss values of T30 sample. The cooking loss values of wet noodles ranged around 18 to 19 %.

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

The increasing of swelling index of dough is caused the capability of glucomannan to reduce pore size and increase the pore numbers with uniform size [63]. The synergistic interaction between these hydrocolloids and gluten protein results stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices[64]. The cross-linking and polymerization involving functional groups of gluten protein, κ-carrageenan and glucomannan determined binding force with each other. The stronger attraction between molecules composed cross-linking reduces the particles or molecules loss during cooking[64-66]. Stability of the network dimensional structure of protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in dough of wet noodles that determined tensile strength, swelling index and cooking loss of wet noodles. Schefer et al. [27] and Widyawati et al. [15] explained that phenolic compounds can disturb the interaction between 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 π-π stacking. The phenolic compounds of butterfly pea extract were interacted with κ-carrageenan, glucomannan, protein or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt a three-dimensional networking of interaction among gluten protein, κ-carrageenan and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulphide bridges to form of thiols radicals [65,66]. These compounds can form complexes with protein and hydrocolloids leading to structural and functional changes and influence gel formation though aggregation formation and disulphide bridges breakdown [26,27,67].

Color of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction between the composite flour and butterfly pea extract ($p \leq 0.05$). The L^*, a^*, b^*, C, and ^oh increased with increasing the ratio of composite flour and the concentration of butterfly pea extract. Most of color parameters values were lower than the control (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas the increasing of amount of butterfly pea extract changed all color parameters. The ranging of *L**, *a**, *b**, *C*, and ^{o}h 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 grew with going up the κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. Chroma and hue of wet noodles decreased with increasing of κ-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 κ-carrageenan in composite flour also supported water holding capacity of wet noodles that influenced color. κ-carrageenan was synergized with glucomannan to produce strong stable network that involved sulfhydryl groups. Tako and Konishi [68] reported that κ-carrageenan is capable to associate making polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making three-dimensional network structure that implicated all component of composite flour was very complicated because they involved polar and non-polar functional groups and many kinds of interaction of them. These were influenced water content and water activity of wet noodles that were impacted wet noodle color. The other cause of wet noodles was anthocyanin pigment from butterfly pea extract. Gamage et al. [69] reported that anthocyanin pigment of butterfly pea is delfinidin-3-glucoside having blue color. Increasing of extract concentration declined lightness, redness, yellowness and chroma as well as changed hue color from yellow to be green until 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. [70] and Padmawati et al. [71] also founded similarity of their research. Anthocyanin pigment of butterfly pea extract can be interacted with color of stinky lily and κ-carrageenan impacted color change of wet noodles. Thus, the sample T0 is yellow color, T15 is green color and T30 is blue color. Color intensity showed as chroma values of yellow values increased along with higher proportion of κ-carrageenan at the same concentration of butterfly pea extract, but the higher concentration of butterfly pea extract declined green and blue colors of wet noodles at the same proportion of composite flour. Wet noodle color also estimated to be influenced by the phenolic compound content which underwent polymerization or degradation during the heating proses. Widyawati et al. [28] reported that bioactive compounds in pluchea extract can change wet noodle color because of discoloration of pigment during cooking. K2T30 was wet noodles having strongest blue color due to different interaction of anthocyanin and hydrocolloid compounds, especially κ-carrageenan that were capable to reduce intensity of blue color or chroma values.

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

TPC, TFC and TAC were shown in Fig. 5. The TPC and TFC of wet noodles were significantly influenced by interaction between two parameters of the ratio of composite flour and the concentration of butterfly pea extracts ($p \leq 0.05$). The highest proportion of κ-carrageenan and butterfly pea extract resulted the highest TPC and TFC. The K2T30 had the highest TPC and TFC as ~ 207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. While the TAC of wet noodles was only influenced by the concentration of butterfly pea extract, the increase in extract addition leading to an increase in TAC. The extract substitution at T30 was obtained about 3.92±0.18 mg delfidine-3-glucoside/kg dried noodles of TAC. Based on Pearson correlation, TPC of wet noodles was strong and positive correlated with TFC at T0 treatment (r= 0.955), T15 treatment (r=0.946), T30 (r=0.765), while TPC of samples was weak and positive correlated with TAC at T0 treatment (r=0.153) and T30 (r=0.067), except the samples at T15 treatment had correlation coefficient -0.092 (Table 7). The bioactive compounds of wet noodles were correlated with quality properties and antioxidant activity (AOA). Dominant anthocyanin pigment from butterfly pea extract is delphinidin [72] around 2.41 mg/g samples [73] that has free more acyl groups and aglycone structure [74] and can be used as natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is potential as antioxidant agent through free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling [75,76]. Nevertheless, butterfly pea extract also composes tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6”-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose) [20,21], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids [74], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexen, 1-methyl-4(1-methylethylideme), hirsutene [77,78], that contribute to have antioxidant activity [18,78]. *Clitoria ternatea* shows potential as antioxidant activity based on an 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^{2+} reducing power assays [78]. TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in composite flour and the higher concentration of butterfly pea extract. Zhou et al. [79] claimed that glucomannan in stinky lily has hydroxyl groups that can be reacted with Folin Ciocalteus's phenol reagent. Devaraj et al. [80] reported that 3,5-acetyltalbulin is flavonoid compounds in glucomannan can be bound complexes with $AlCl_3$.

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 Fig. 5. The proportion of composite flour and concentration of butterfly pea extracts significantly affected the DPPH ($p \leq 0.05$). The noodles had DPPH ranging from 3 to 48 mg GAE/kg dried noodles. The noodles including composite flour of K0 and K1 and without of butterfly pea extracts (K0T0 and K1T0) had lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest DPPH. Pearson correlation showed that TPC and TFC were strong and positive correlated with DPPH (Table 7). Correlated coefficient values (r) between TPC and AOA at T0, T15 and T30 treatments were 0.893, 0.815, and 0.883, respectively. Whereas r values between TFC and DPPH at T0 treatment were 0.883, at T15 treatment were 0.739, and at T30 treatment were 0.753. However, correlation coefficient values between TAC and AOA at T0, T15 and T30 treatments were 0.123, 0.127, and 0.194, respectively. Interaction among glucomannan, phenolic compounds, amylose, gliadin and glutelin in dough of wet noodles determined number and position of free hydroxyl groups of them that influenced TPC, TFC, and DPPH. Widyawati et al. [46] said that free radical inhibition activity and chelating agent of phenolic compounds depends on position of hydroxyl groups and conjugated double bond of phenolic structures. The values of TPC, TFC and DPPH increased with higher level of stinky lily flour and κ-carrageenan proportion and butterfly pea extract significantly up to 18 and 2% (w/w) glucomannan and κ-carrageenan and 15% (w/w) extract, but the using of 17 and 3% (w/w) glucomannan and κ-carrageenan and 30% (w/w) extract showed a significant decrease. This showed that the use of stinky lily flour and k-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 concentration of butterfly pea extracts ($p \leq 5\%$). FRAP was used to measure the capability of antioxidant compounds to reduce Fe^{3+} ion to be Fe^{2+} ion. FRAP capability of wet noodles was lower than DPPH ranging 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without κ-carrageenan and butterfly pea extracts (K0T0) had lowest FRAP, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest FRAP. Pearson correlation values showed that TPC dan TFC at T0 and T30 treatments had strong and positive correlated to FRAP activity, but T15 treatment possessed weak and positive correlation (Table 7). Correlation coefficient (r) values of TAC at T0 treatment was weak and positive correlated to FRAP samples, but r values at T15 and T30 treatments owned weak and negative correlation (Table 3). The correlation between DPPH and FRAP activities was obtained that DPPH method was highly correlated with FRAP method at T0 and T30 treatments and lowly correlated at T15 treatment (Table 3). Based on DPPH and FRAP methods showed that capability of wet noodles to scavenge free radical was higher than them to reduce ferric ion. It proved that bioactive compounds of wet noodles were more potential as free radical scavengers or hydrogen donors than as donor electron. Compounds that have capability to reducing power can act as primary and secondary antioxidant [81,82]. Poli et al. [83] said that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al. [84] claimed that a secondary antioxidant is natural antioxidant that has capability to reduce ferric ion (FRAP). Based on AOA assay, the results showed that phenolic compounds indicated strong and positive correlation with flavonoid compounds because of they are major phenolic compounds that are potential as antioxidant activities pass through highly effective scavenger of various free radicals. The effectivity of flavonoid compounds to inhibit free radicals and chelating agents is influenced by number and position of hydrogen groups and conjugated diene at A, B, and C rings [85-87]. Previous studies have proven that TPC and TFC exhibit significant contributor to scavenge free radicals [88-90]. However, TAC showed a weak correlation with TFC, TPC or AOA, although Choi et al. [89] stated that TPC and anthocyanins have a significant and positive correlation with AOA but anthocyanins were insignificantly correlated with AOA. Different structure of anthocyanins in samples determines AOA. Polymer anthocyanins or anthocyanin complexed with other molecules assign capability of them to electron or hydrogen donors. Martin et al. [91] informed that the anthocyanins are major groups of phenolic pigments that are an essential antioxidant activity depend on a steric hindrance of their chemical structure, such as number and position of hydroxyl groups and the conjugated doubles bonds, as well as the presence of electron in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positive correlated with FRAP assay due to the role of phenolic compounds involved reducing power that contributed them to donor electron. Paddayappa et al. [82] reported that the phenolic compounds are capable to embroiled redox activities with action as hydrogen donor and reducing agents. The weakly relationship between TPC or 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 hedonic method, showed that composite flour and butterfly pea extract additions significantly influenced color, aroma, taste, and texture preferences ($p \leq 0.05$) (Table 4). 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. The using of butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensity of wet noodle's color that resulted color degradation from yellow, green until blue color impacted color preference of wet noodles. Nugroho et al. [48] also informed that addition of butterfly pea extract upgraded preference of panelist to dried noodles. Aroma of wet noodles was also affected by two parameters of treatments, the results showed that the higher proportion of stinky lily caused the stronger musty smell of wet noodles. Utami et al. [92] claimed that oxalic acid of stinky lily flour contributes to odor of rice paper. Therefore, a high proportion of k-carrageenan can reduce the proportion of stink lily flour, thereby increasing the panelist's preference for aroma. Sumartini and Putri [93] informed that panelist is more like noodles substituted the higher κ-carrageenan. Kurniadi et al. [94] and Widyawati et al. [15] said that κ-carrageenan is odorless material which doesn't result aroma of wet noodles. Neda et al. [77] added that volatile compounds of butterfly pea extract can mask musty smell of stinky lily flour, such as pentanal and mome inositol, Padmawati et al. [71] informed that they can gave sweety and sharp aroma. Taste preference of panelist to wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin [95] due to Maillard reaction of stinky lily flour processing. Nevertheless, using of butterfly pea extract at higher concentration of wet noodles increased bitter taste related to tannin compounds in this flower, this is supported by Hasby et al. [96] and Handayani and Kumalasari [97]. Effect of composite flour proportion and butterfly pea extract also appeared to texture preference of wet noodles. Panelist was likely wet noodles that was not break up easily that K3T0 samples were chewy and elastic wet noodles, this was supported by tensile strength of wet noodles because of the different concentration of butterfly pea extract. The addition butterfly pea extract at higher concentration resulted sticky, break easy and less chewy wet noodles [26,27,85,97] due to competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel [98]. Based on index effectiveness test, the noodles including composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment with total score of 1.0504.

Conclusions

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

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Conflict of Interest

The authors declare no conflict of interest

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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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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.

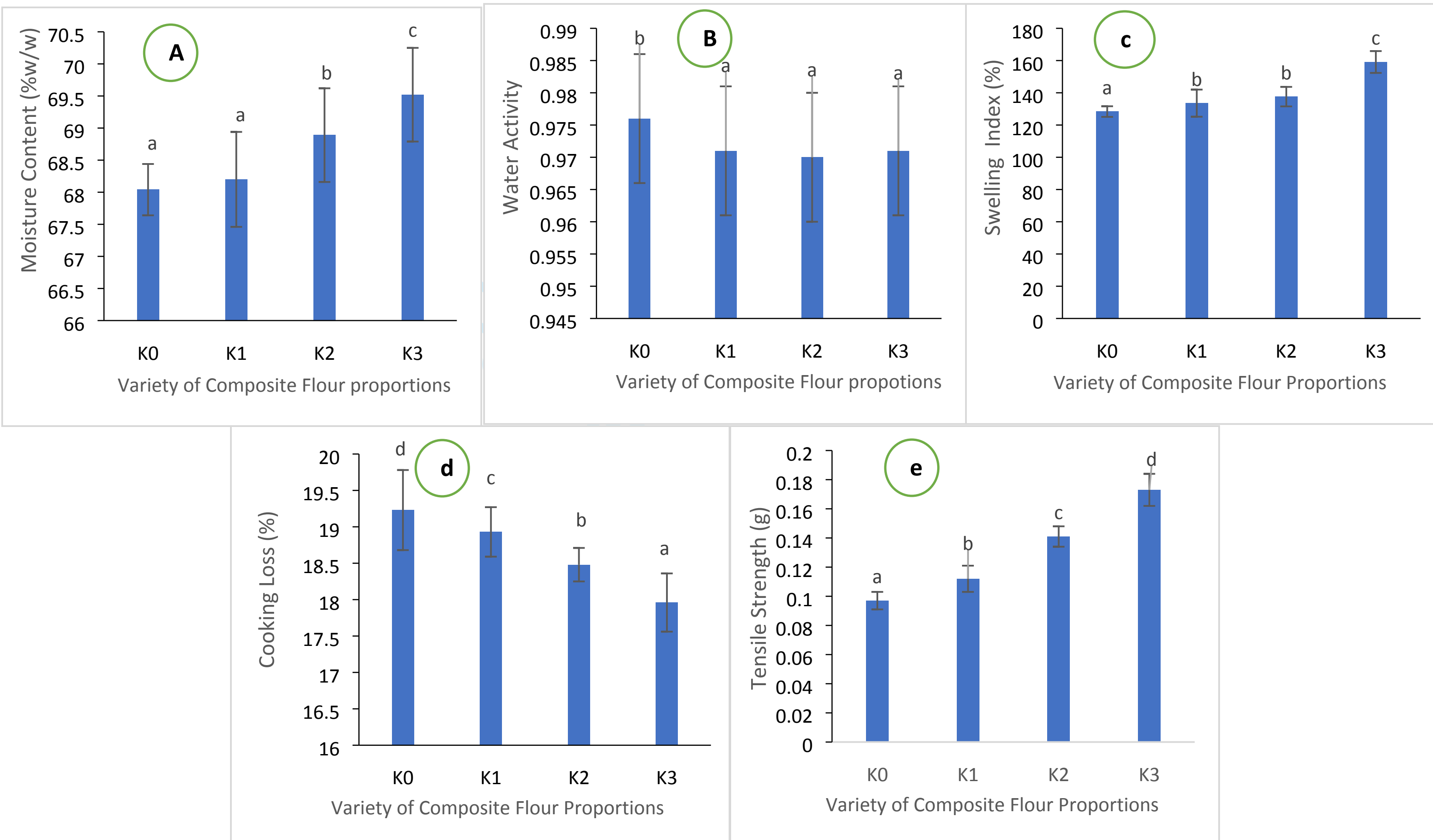

Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets)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

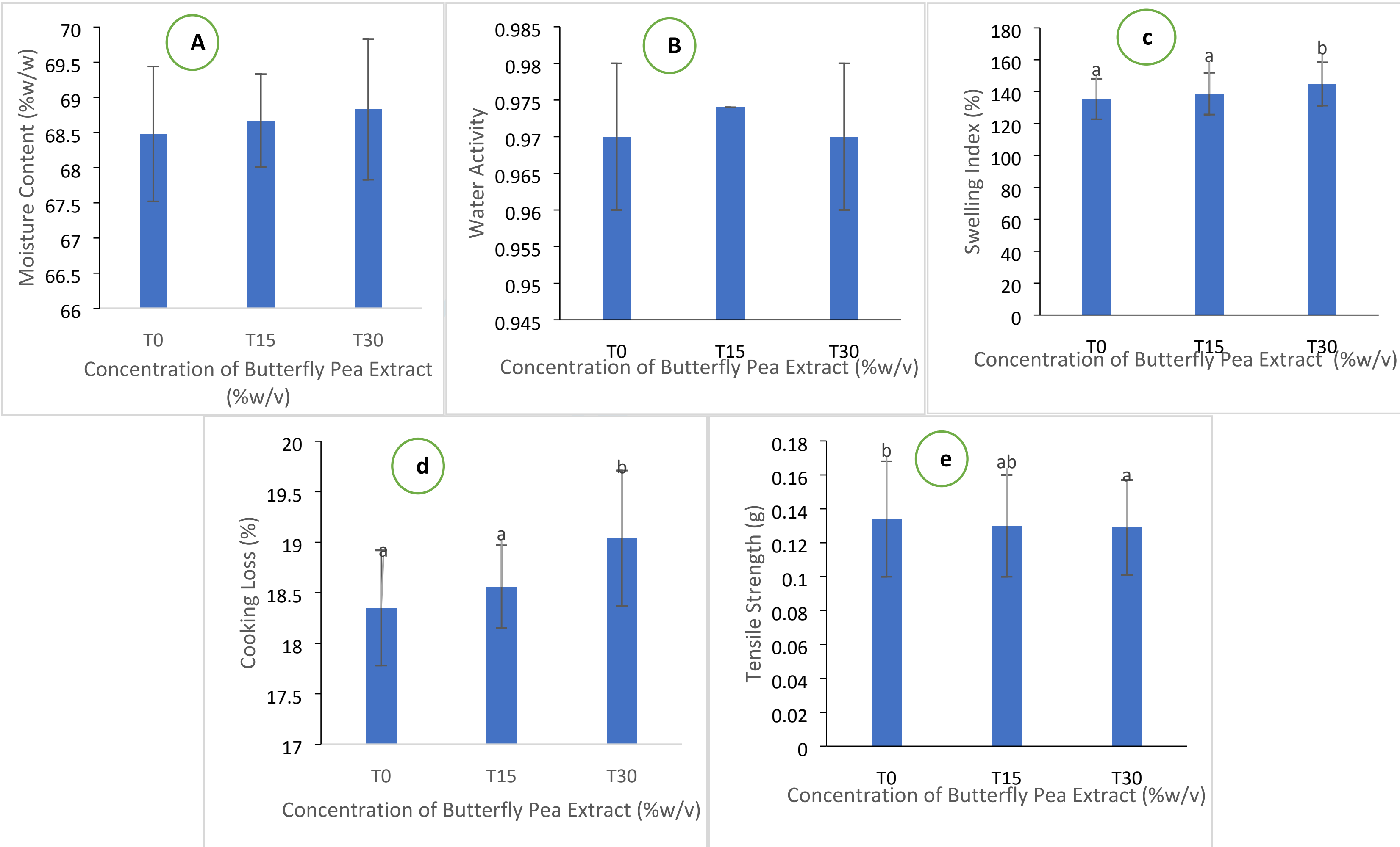

Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

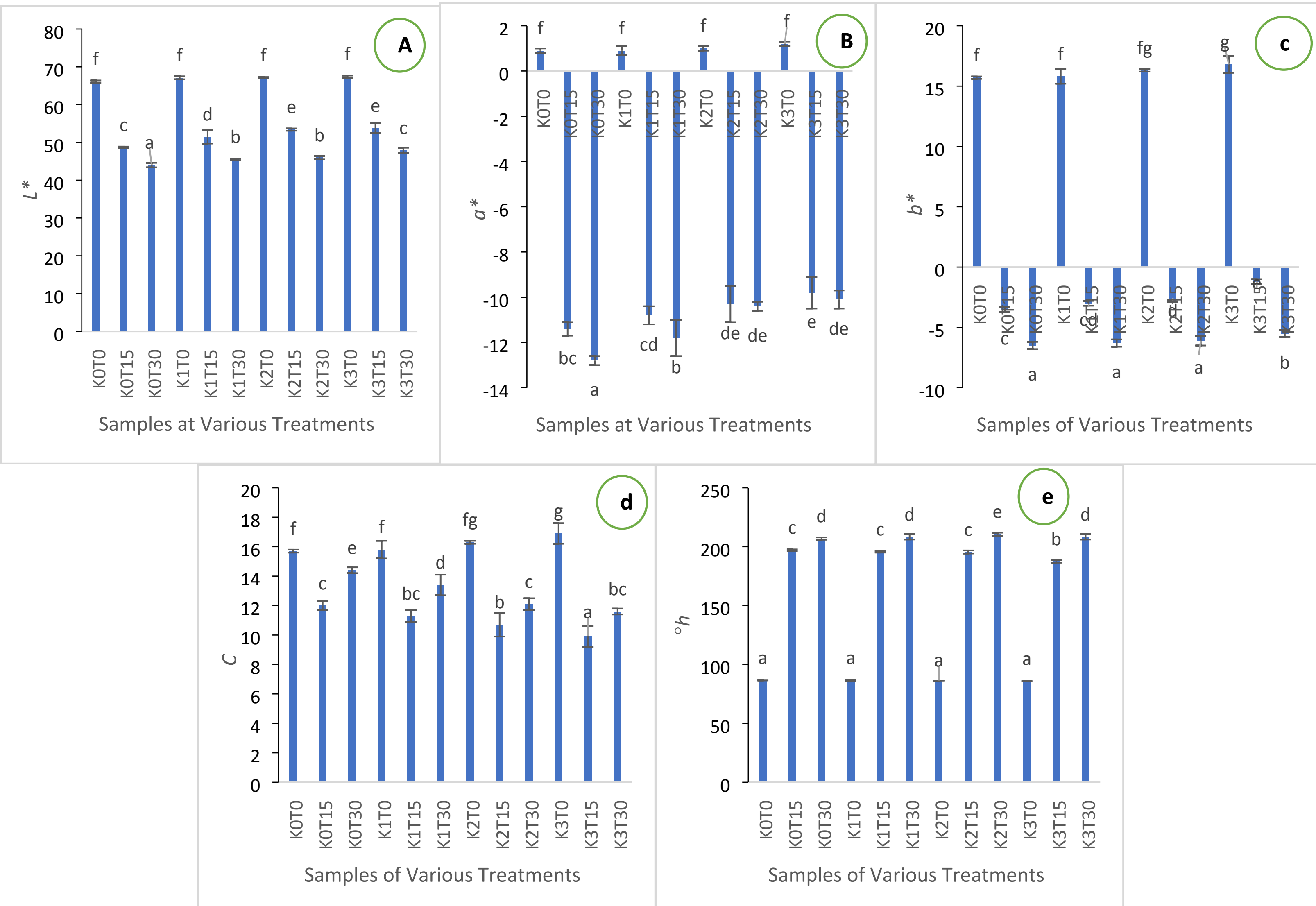

Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

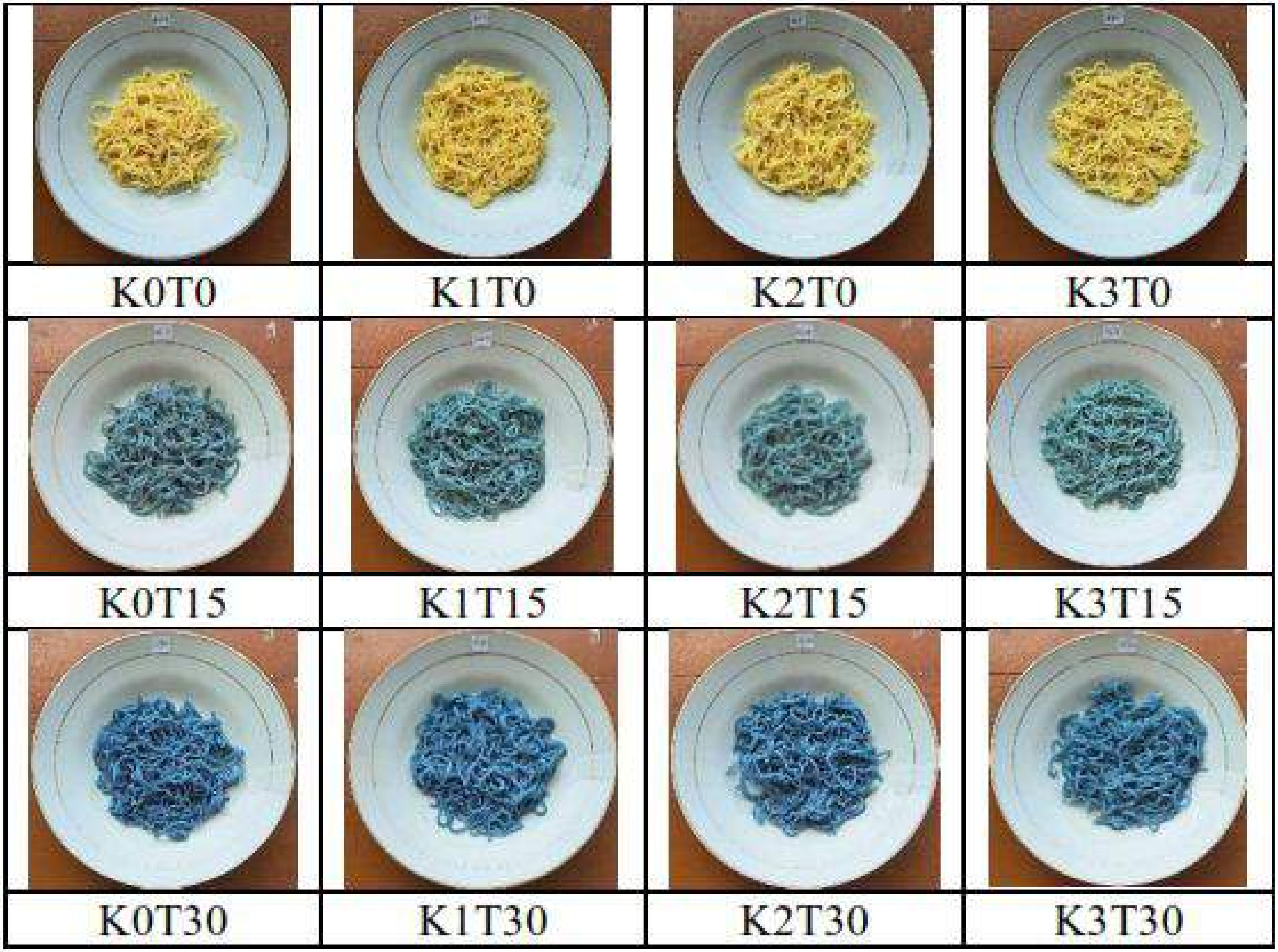

Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

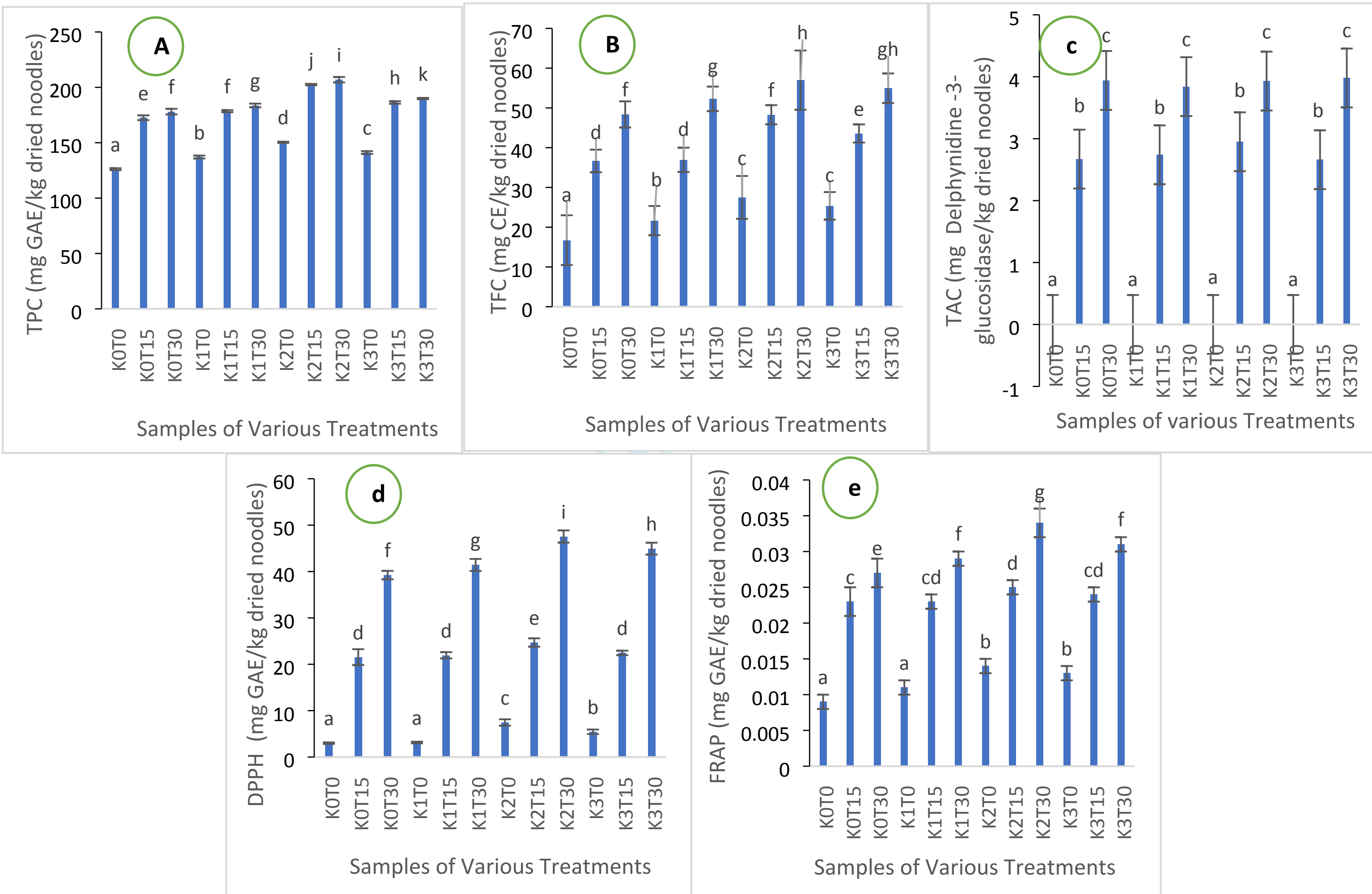

Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different, p ≤ 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[a]	7.41±3.80[a]	8.71±3.16[a]	10.78±2.86[abcde]	0.1597
K0T15	8.96±3.38[b]	7.75±3.89[b]	9.35±3.36[cde]	11.19±3.10[abcd]	0.6219
K0T30	8.93±3.50[bc]	7.71±3.76[c]	9.26±3.17[bcd]	11.13±3.09[a]	0.6691
K1T0	8.74±3.62[a]	8.13±3.56[ab]	9.58±3.13[ab]	11.33±3.12[de]	0.4339
K1T15	9.98±3.06[bc]	8.40±3.28[c]	10.16±2.59[def]	10.61±2.82[ab]	0.7086
K1T30	10.08±3.28[bc]	9.10±3.08[c]	10.44±2.32[bcd]	10.36±2.81[ab]	0.7389
K2T0	10.41±3.01[a]	9.39±3.27[ab]	11.04±2.44[ab]	10.55±2.60[cde]	0.3969
K2T15	10.8±2.85[bc]	9.26±3.10[c]	10.11±2.76[f]	10.89±2.65[abcd]	0.9219
K2T30	10.73±3.02[c]	9.10±3.46[c]	9.85±2.99[def]	10.16±2.74[abc]	0.9112
K3T0	10.73±3.42[a]	9.19±3.38[b]	9.93±2.50[bc]	10.34±2.84[e]	0.5249
K3T15	10.91±3.23[bc]	9.48±3.56[c]	10.45±2.82[cde]	10.49±2.68[bcde]	0.9235
K3T30	10.88±3.14[c]	9.49±3.59[c]	10.81±2.74[ef]	10.86±2.60[bcde]	**1.0504**

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, $p \leq 5\%$.

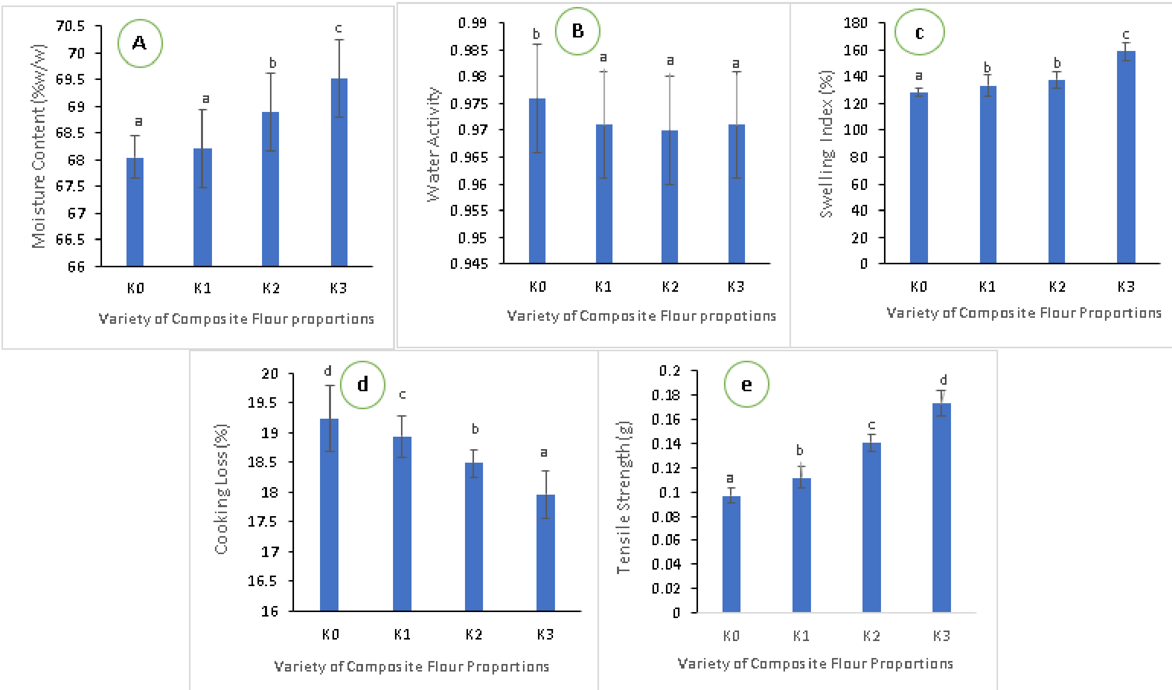

Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets)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

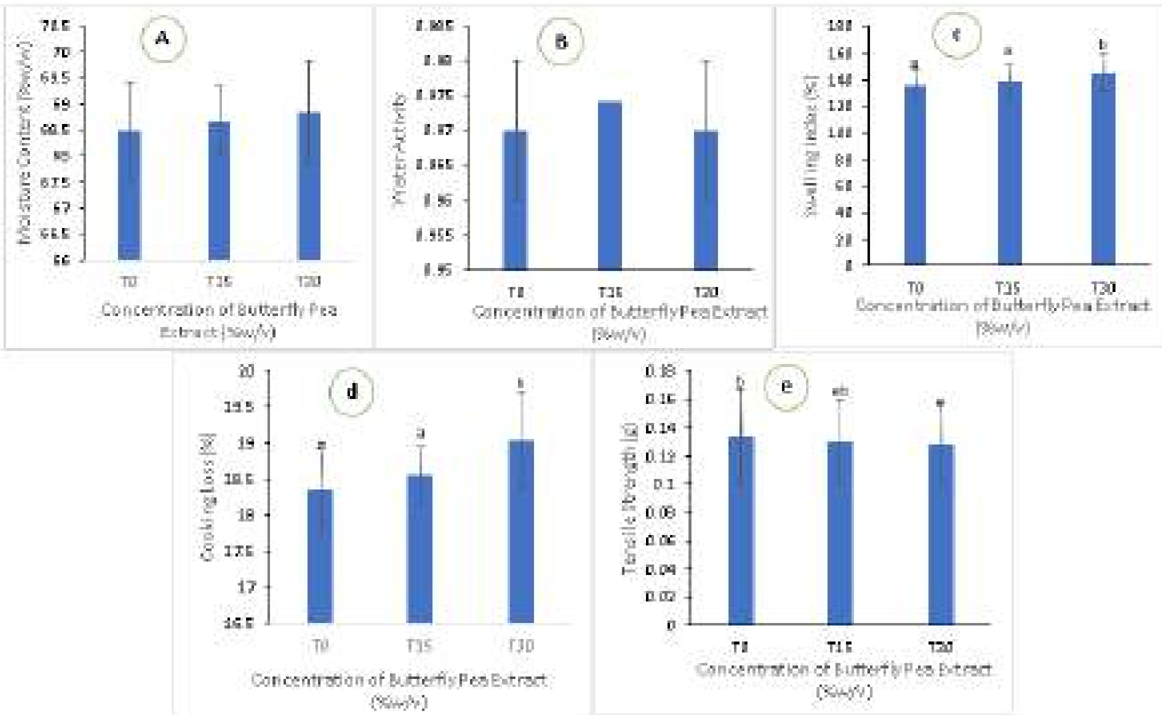

Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

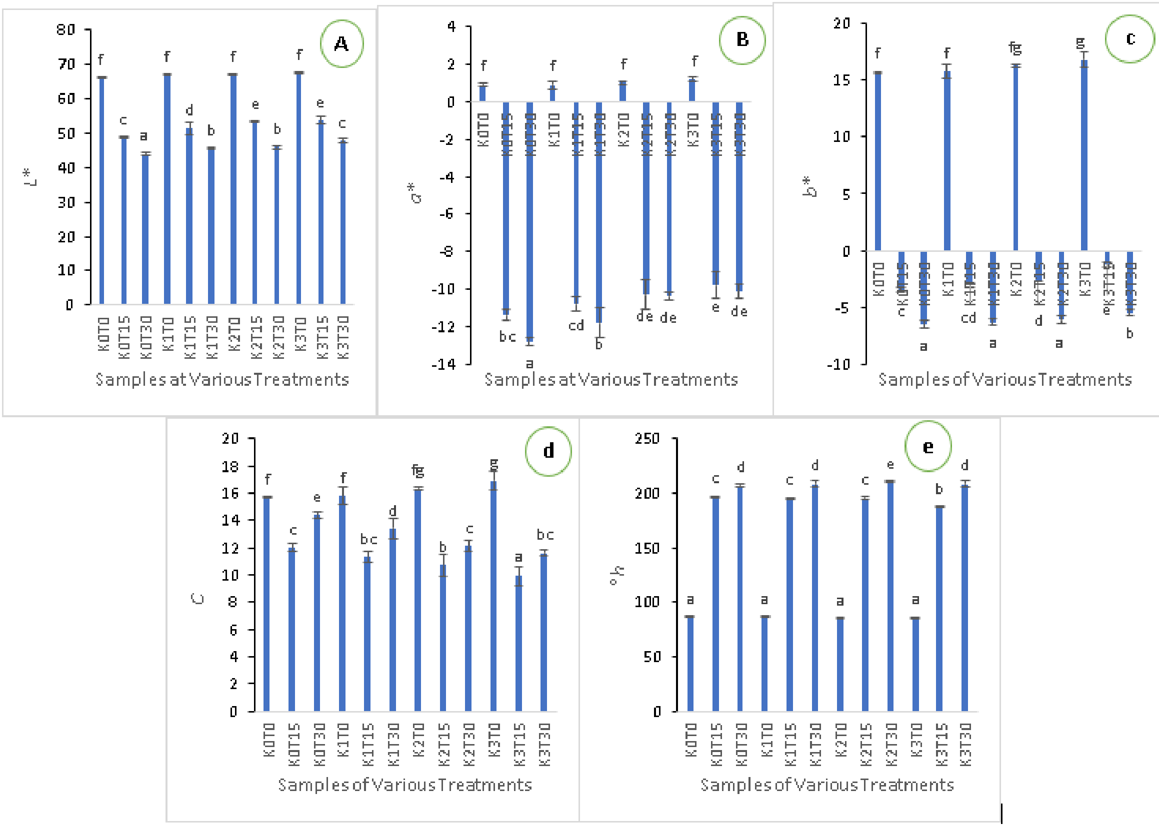

Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

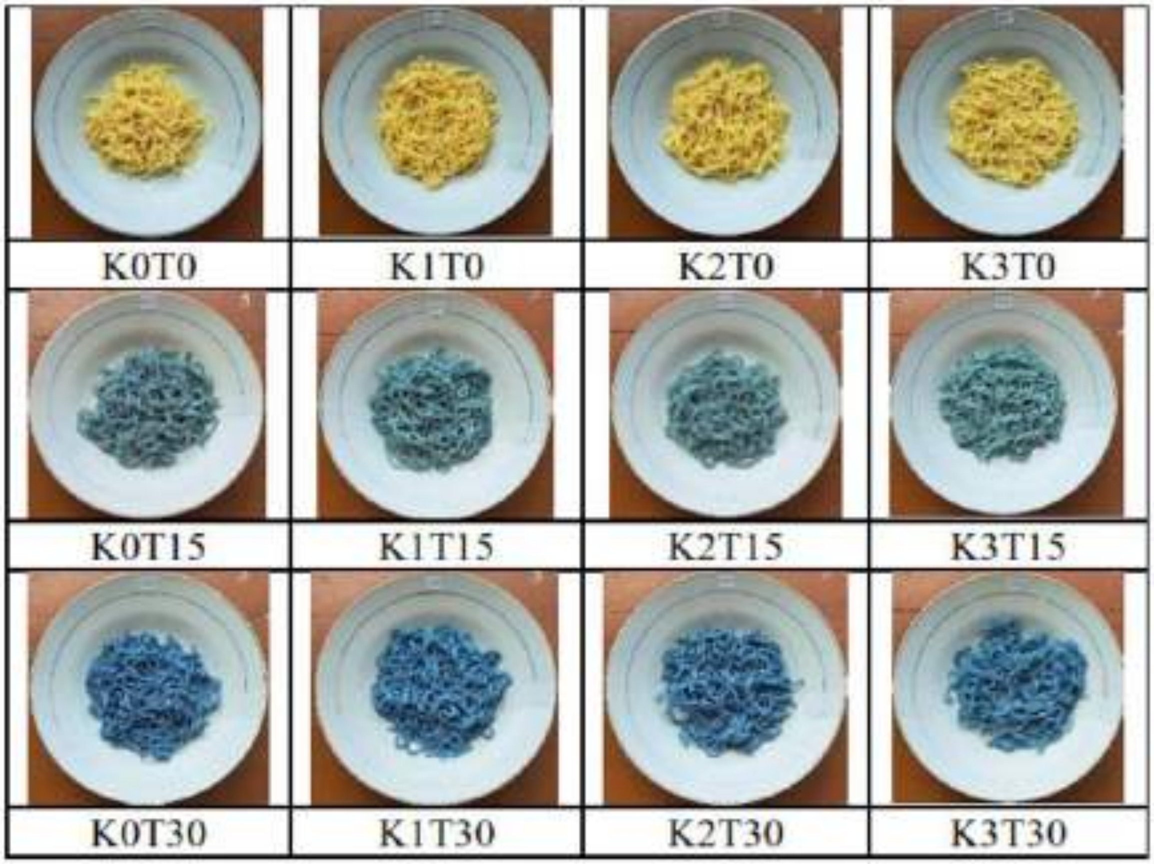

Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

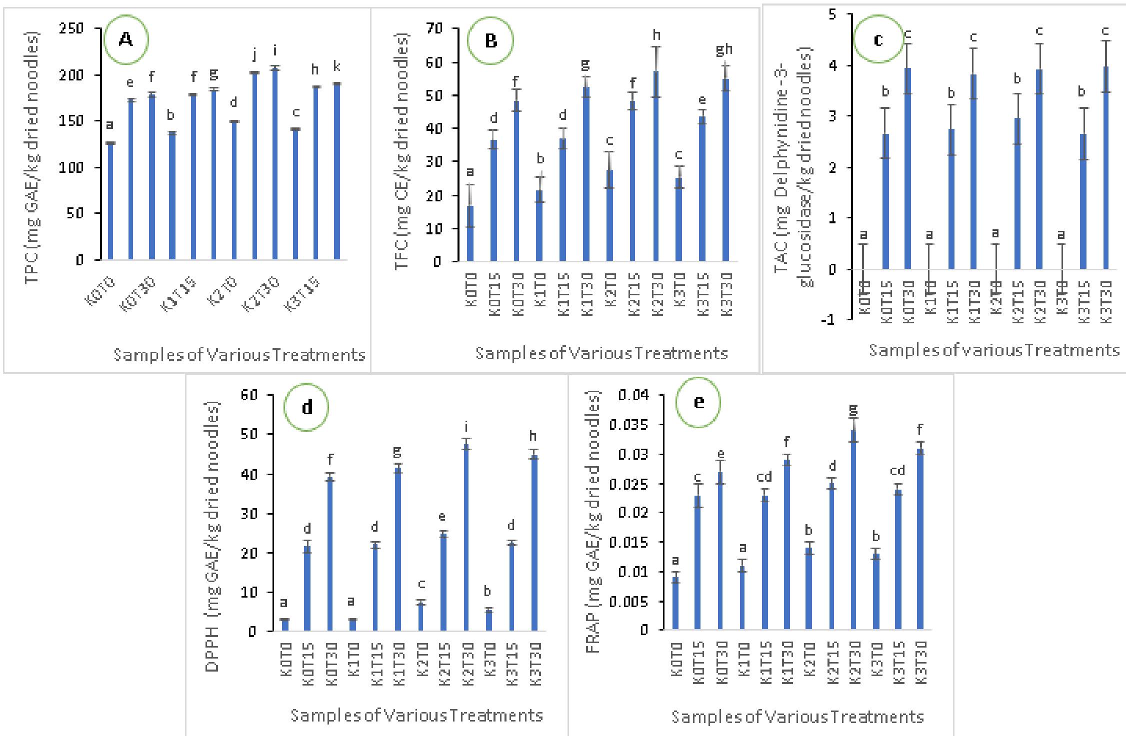

Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different, p ≤ 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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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^{a}	7.41±3.80^{a}	8.71±3.16^{a}	10.78±2.86^{abcde}	0.1597
K0T15	8.96±3.38^{b}	7.75±3.89^{b}	9.35±3.36^{cde}	11.19±3.10^{abcd}	0.6219
K0T30	8.93±3.50^{bc}	7.71±3.76^{c}	9.26±3.17^{bcd}	11.13±3.09^{a}	0.6691
K1T0	8.74±3.62^{a}	8.13±3.56^{ab}	9.58±3.13^{ab}	11.33±3.12^{de}	0.4339
K1T15	9.98±3.06^{bc}	8.40±3.28^{c}	10.16±2.59^{def}	10.61±2.82^{ab}	0.7086
K1T30	10.08±3.28^{bc}	9.10±3.08^{c}	10.44±2.32^{bcd}	10.36±2.81^{ab}	0.7389
K2T0	10.41±3.01^{a}	9.39±3.27^{ab}	11.04±2.44^{ab}	10.55±2.60^{cde}	0.3969
K2T15	10.8±2.85^{bc}	9.26±3.10^{c}	10.11±2.76^{f}	10.89±2.65^{abcd}	0.9219
K2T30	10.73±3.02^{c}	9.10±3.46^{c}	9.85±2.99^{def}	10.16±2.74^{abc}	0.9112
K3T0	10.73±3.42^{a}	9.19±3.38^{b}	9.93±2.50^{bc}	10.34±2.84^{e}	0.5249
K3T15	10.91±3.23^{bc}	9.48±3.56^{c}	10.45±2.82^{cde}	10.49±2.68^{bcde}	0.9235
K3T30	10.88±3.14^{c}	9.49±3.59^{c}	10.81±2.74^{ef}	10.86±2.60^{bcde}	**1.0504**

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.

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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 qualtiy.
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

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

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Abstract

The ~~improving~~ improvement of wet ~~noodles~~ noodles' qualities, sensory, and functional properties ~~were~~ was ~~done~~ made by using the composite flour base added with the butterfly pea flower extract. The composite flour ~~of~~ consisted of wheat flour and ~~,~~ stink lily flour, and κ-carrageenan at ~~various~~ ratios ~~ratio~~ of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed a randomized block design with two~~2~~ factors, namely the composite flour and the concentration of butterfly pea flower extract, ~~that~~ 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 ~~were~~ significantly affected the ~~the~~ color profile, sensory properties, bioactive compounds, and antioxidant activit~~y~~ies of wet noodles. However, each factor also ~~had~~ significantly influenced ~~of~~ the physical properties ~~from~~ of wet noodles, such as moisture content, water activity, tensile strength, swelling index, and cooking loss. The us~~eing~~ of κ-carrageenan up to 3 % (w/w) in ~~composite flour~~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-κ-carrageenan at a ratio of 80:17:3 (% w/w) ~~was~~ had the ~~best~~ highest consumer acceptance based on hedonic sensory score.

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

Introduction

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

~~Previous~~ A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional values of noodles by increasing the biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and prolonging gastric emptying time[8,9]. However, adding ~~of~~ stink lily flour ~~in~~ to base noodles flour ~~had~~ resulted in wet noodles' limited elasticity and tensile strength~~limited on elasticity and tensile strength of wet noodles~~[10,11]. ~~Then~~Therefore, the κ-carrageenan was ~~added~~ introduced to improve the texture properties of wet noodles. Those components ~~were a collaborates~~ collaborated with glucomannan to form ~~cross linking~~cross-linking with glutenin and gliadin by inter-~~n~~ and intra-molecular bonds, ~~leading to improving~~ improving ~~of~~ noodle texture [12-14]. Widyawati et al. [15] explained that using ~~of~~ the composite flour consisting ~~consisted~~ of wheat flour, stink lily flour, and κ-carrageenan can ~~look up~~improve the swelling index, total phenolic content (TPC), total flavonoid content (TFC), ~~and~~ and 2,2-diphenyl-1-picrylhydrazyl ~~DPPH~~ free radical scavenging activity (DPPH), which ~~that~~ influences~~s~~ ~~an~~ the effectivity of bioactive compounds ~~on~~ in the composite flour ~~as~~ 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~~Therefore, addition of the other ingredient enriched phenolic compounds is done to increase functional values of composite flour as antioxidant~~. Czajkowska–González et al. [16] ~~informed~~ mentioned that ~~elaborate~~ incorporating~~of~~ ~~natural antioxidant sources enriched~~ phenolic ~~compounds~~ antioxidants from natural sources can improve the functional values of bread. Widyawati et al. [15] ~~has~~ added pluchea extract to increase the TPC, TFC, and DPPH ~~free radical scavenging activity~~ of wet noodles;~~,~~ ~~but~~ however, this resulted in an unattractive ~~the weakness of~~ wet noodle color. Therefore, it is necessary to incorporate other ingredients ~~is not attractive that it is necessary to look for 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~~n~~ herb plant from the ~~,~~ Fabaceae family with~~, having~~ various flower color~~s flower~~, such as purple, blue, pink, and white [17]. ~~–~~This flower has phytochemical compounds ~~which~~ that ~~are~~ benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides [20,21]. Anthocyanins of the butterfly pea flower has been used as natural colorants in many food products [22,23], one of them is wet noodle~~s~~ [24,25]. 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 ~~the~~ benzene rings [26]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility~~This interaction involves covalent and non-covalent bonds of them which were influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility~~ [27]. A p~~P~~revious study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf [15,28], gendarussa leaf (*Justicia gendarussa* Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31] ~~establishes~~ contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al. [25] ~~has~~ utilized the natural color of butterfly pea flower extract to make wheat flour-based wet noodles, resulting in higher total anthocyanin, polyphenol, ~~and~~ DPPH ~~scavenging activity~~ 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 κ-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.~~utilized natural color of butterfly pea flower extract to make wet noodles base wheat flour that results the higher total anthocyanin, polyphenol, DPPH scavenging activity and reducing power than the control samples and the use of this extract can improve color preference and reduce the cutting force, tensile strength, and extensibility of cooked noodles. 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 κ-carrageenan) has not been studied. Therefore, the study was conducted to decide the effect of composite flour and butterfly pea flower extract to quality, bioactive content, antioxidant activity, and sensory properties of wet noodles.~~

Materials and Methods

Raw materials and preparation

Butterfly pea flowers were~~as~~ obtained from Penjaringan Sari garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flowers were~~as~~ sorted, washed, dried ~~by~~ 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 to get three concentrations of butterfly pea extract: ~~of~~ 0 (T1), 15 (T15), and 30 (T30) (% w/v). The ~~three composite~~three-composite flours proportions were prepared ~~with a~~by mixing ~~of~~ wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and κ-carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

Chemical and reagents

~~The G~~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). Distill~~at~~ed water was purchased ~~by~~ from a local market (PT Aqua Surabaya, Surabaya, Indonesia).

Wet noodles preparation

Wet n~~N~~oodles were prepared based on the modified formula of Panjaitan et al. [11], 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. ~~The~~ S~~s~~alt, water, and fresh whole egg ~~was~~ were then added and kneaded to form a ~~make~~ dough ~~by~~ using a mixer ~~machine~~ (Oxone Master Series 600 Standing Mixer OX 851, China). The dough was sheeted and cut ~~via~~ using rollers equipped ~~using~~ with cutting blades (Oxone OX355AT, China). Raw w~~W~~et noodle strains ~~s~~ were sprinkled with tapioca flour before heated in boiled water (100 ^{o}C) with a ratio of raw ~~noodles:~~noodles: ~~/~~water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil before being subjected to ~~measure the~~ quality and sensory properties measurements, ~~but~~ whereas uncooked~~the samples~~ noodles ~~without cooking and~~without oil coating were used to analyze ~~the~~ bioactive compounds and antioxidant activity.

Extraction of bioactive compounds of wet noodles

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

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

Moisture content analysis

The wWater content of cooked wet noodles was analyzed based on thermogravimetryusing the thermogravimetric method [32]. About 1 g of the samples were was weighed in a weighing bottle and heated by in a drying oven at 105-110 °C for 1 h. , Tthe processes were followed by weighing nthe samples were and measuringweighed and measured moisture content after weight obtaining a constant of sample weights was constant. The mMoisture content wasis calculated based on the difference of difference in sample weight beforeinitial and obtained after a constant sample weight is reached divided by the initial sample weight, expressed as a percentage of wet base.

Water activity analysis

The wWater activity of cooked wet noodles was analyzed using A_w-meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). Ten grams of10 g the samples were were weighed,d and entered put into in an A_w meter chamber, and analyzed and data recordedto obtain the sample's water activity [33].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles [39]. About 20 cm of the samples were was measured for its tensile strength using a texture analyzer that be equipped by with a Texture Exponent Lite Program and a used noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to be pre-set speed, test speed, and post-test speed at 1 mm/s, 3 mm, and 10 mm/s, respectively. Distance, time, and trigger force were set to ~~were used~~ 100 mm, 5 sec, and 5 g, respectively.

Color analysis

~~10~~ Ten grams of~~g~~ cooked wet noodles were weighed in a chamber, and the color was analyzed ~~color~~ using a color rea~~i~~der (Konica Minolta CR 20, Japan) based on the method of Harijati et al.[35]~~.~~ . The p~~P~~arameters measured~~ment~~ ~~was~~ were lightness (L^*), redness (a^*), yellowness (b^*), Hue (^{o}h), and chroma (C). L^* value ~~is~~ ranged 0-100 ~~that~~ expresses~~d~~ brightness, a^* value shows red color ~~which ha~~with~~s~~ an interval between -80 - +100. b^* value ~~is~~ represents a yellow color ~~that has~~with an interval of -70 - +70 [36]. *C* ~~declares~~ indicates the color intensity and ^{o}h states the color of samples [37].

Swelling index analysis

The ~~Swelling~~ swelling index was determined ~~on~~ using ~~the~~ a modified method ~~of~~ by Islamiya et al.[38]. 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 ~~analyzed to measure~~measured to observe the capability of raw wet noodles to absorb water that increased the weight of raw wet noodles ~~increased~~ [39]. The swelling index was measured from the difference in noodle weights before and after boiling.

Cooking loss analysis

The c~~C~~ooking loss of the raw wet noodles was analyzed ~~on~~ using ~~the~~ a modified method ~~of~~ by Aditia et al.[40]. The cooking loss expresses the weight loss of wet noodles ~~for~~ during cooking, ~~that is signed~~indicated by the cooking water that turn to cloudy and thick [41]. About 5 g of the raw wet noodles ~~were~~ was weighed in a chamber and cooked in 150 mL boiled water (100 ºC) for 5 min.~~,~~ T~~t~~hen, the sample~~s~~ ~~were~~ was drained and dried ~~by~~ in a drying oven at 105 ºC until the weight of the sample~~s~~ was constant.

Total phenolic content analysis

The t~~T~~otal phenolic content of the wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method ~~of~~ by Eyele et al.[42]. About 50 μL of the extract was added with 1 mL of 10 % Folin-Ciocalteu's phenol reagent in a 10 mL volumetric flask, ~~shaken~~homogenized, and incubated for 5 min. Then, 2 mL of 7.5 % Na_2CO_3 was added, and the volume was adjusted to 10 mL with ~~distillated~~ distilled water. ~~Solution~~ The solution's absorbance was measured spectrophotometrically ~~absorbance~~ at λ 760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference ~~was~~ used was gallic acid, and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Total flavonoid content analysis

Total flavonoid content was analyzed ~~on~~ using the modified method ~~using~~ by Li et al.[2013]. The procedure began with mixing 0.3 mL of 5 % $NaNO_2$ and 250 μL of noodle extract in a 10 mL volumetric flask and ~~was added with 0.3 mL of 5% $NaNO_2$ and~~ incubating the mixture ~~ed~~ for 5 min~~ in a 10 mL volumetric flask~~. ~~After 5 min of incubation~~Afterward, 0.3 mL of 10 % $AlCl_3$ was added into the volumetric flask. After 5 min, 2 mL of 1 M NaOH was added, and the volume was adjusted to 10 mL with ~~distillated~~ distilled water. The s~~S~~ample~~s~~ ~~were~~ was ~~mixed and~~ homogenized ~~before~~ prior to ~~was~~ analysis~~zed~~ using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ. 510 nm. The result was determined using a (+)-catechin standard reference and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

Total anthocyanin content analysis

Total anthocyanin content was determined ~~on~~ using the method of Giustl and Wrolstad [44]. About 250 µL of the sample~~s~~ ~~were~~ was added with buffer solutions at pH 1 and pH 4.5 in different 10 mL test tubes. ~~And~~ T~~t~~hen, each ~~of samples~~sample was mixed and incubated for 15 min and measured at λ 543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The a~~A~~bsorbance (A) of samples was calculated with formula: A $=(A\lambda 543 - A\lambda 700)pH\ 1.0 - (A\lambda 543 - A\lambda 700)pH4.5$. The total anthocyanin content (mg/mL) was calculated ~~by~~ with formula: $\frac{AxMWxDFx1000}{\varepsilon x\, l}$, ~~.~~ w~~W~~here A was the absorbance, MW was the molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29000 L cm^{-1} mol^{-1}).

2,2-Diphenyl-1-picrylhydrazyl ~~DPPH~~ free radical scavenging activity

DPPH analysis ~~scavenging activity~~ was measured based on the methods of Shirazi et al. [45] and Widyawati et al.[46]. Briefly, 10 µL 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 s~~S~~olution was centrifuged at 5000 rpm for 5 min, and the absorbance of samples was measured at λ~~.~~ 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The a~~A~~ntioxidant activity of the samples was stated as an inhibition capacity with gallic acid as the standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Ferric reducing antioxidant power

FRAP analysis ~~was~~ was performed using ~~used~~ the modified method of Al-Temimi and Choundhary [47]. Approximately 50 µL of the extract in a test tube was added with 2.5 mL of phosphate buffer solution at p~~P~~H 6.6 and 2.5 mL of 1 % potassium ferric cyanide, shaken and incubated for 20 min at 50 °C. After incubation ~~20 min~~, 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-distill~~at~~ed water and 2.5 mL of 0.1 % ferric chloride and incubated for 10 min. After incubation, samples were measured with absorbance at λ = 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). ~~Antioxidant capacity was used~~ G~~g~~allic acid was used as the standard reference, and the results were expressed ~~as~~ in mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Sensory evaluation

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

Design of experiment and statistical analysis

The ~~Design~~ design of 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 κ-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 ~~done~~ performed in three replications. The homogenous ~~data of~~ triplicate data ~~analysis was~~were expressed as the mean ± SD. The one-way analysis of variance (ANOVA) was done, and Duncan's New multiple range test (DMRT) was used to determine ~~for~~ the differences between means ($p \le 0.05$) using the statistical analysis applied SPSS 23.0 software (SPSS Inc., Chicago, IL, USA).

Results and discussions

Quality of Wet Noodles

The q~~Q~~uality results of the wet noodles, including moisture content, water activity, tensile strength, swelling index, cooking loss, and color, ~~was~~ are shown in Table 2 and Fig.1, 2, 3, and 4. Moisture content and water activity (A_w~~W~~) of raw wet noodles were only significantly influenced by the various ratios of composite flour ($p \le 0.05$) (Fig. 1). However, the interaction of the two factors, the ~~difference in the ratio~~ratios of composite flour and the concentrations of butterfly pea extract, or the concentrations of butterfly pea extract itself~~,~~ did not ~~have~~ give any significant effects on the water content and ~~AW~~ A_w of wet noodles ($p \le 0.05$) (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~~s~~ had the highest ratio of κ-carrageenan. ~~The~~ An ~~increasing~~ increase of κ-carrageenan proportion influenced the amount of free and bound water in the wet noodle samples, which also ~~that~~ increased the water content of the wet noodles. Water content ~~measures~~ resembles the amount of free and weakly bound water in the samples' pores, intermolecular, and intercellular space ~~of samples~~ [15,28,~~49~~]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules [49~~50~~]. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of gluten network to ~~stability~~ stabilize the gluten network, increasing ~~that increases~~ water binding capacity and retardings the migration of water molecules [50~~1~~,~~52~~]. κ-carrageenan can bind water molecules around 25-40 times [51~~3~~]. The κ-carrageenan can cause ~~the~~ a structure change of gluten protein through electrostatic interactions and hydrogen bonding [52~~4,55~~]. The i~~I~~nteraction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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 is be able tocan establish water mobility in the dough of this the wet noodles. The effect of this interaction of all components of in the composite flour significantly influenced of the amount of free water ($p \leq 0.05$) (Fig. 1). The addition of κ-carrageenan between 1-3_% in the wet noodle formulation reduced the AW A_w by about 0.005-0.006. The capability of κ-carrageenan absorbed to absorb water molecules reduces the water mobility in the wet noodles due to the involving involvement of hydroxyl, carbonyl, and ester sulphate sulfate groups of them to form complex structures [535-57]. The complexity of the reaction among components in the wet noodles to form a three-dimensional networking influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components arranged between of wet noodles and water molecules also specified contributed to the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles was were significantly influenced by each factors of the ratios of composite flour or the concentrations of butterfly pea flower extract ($p \leq 0.05$) (Fig. 1 and 2). However, , but the interaction of the various ratio of composite flour and the concentration of butterfly pea extractbetween the two factors was not significant seen to influenced the tensile strength, swelling index, and- cooking loss of wet noodles ($p \leq$. 0.05) (Table 2). The An increaseing of in the ratio of κ-carrageenan in the composite flour increased the tensile strength and swelling index, and decreased the cooking loss of wet noodles. On the other hand, , but the increasing of the concentration of butterfly pea extract concentration decreased the tensile strength and increased the swelling index and cooking loss of wet noodles. The effect of the Different ratios of the composite flour to affected the tensile strength, which ranged between 0.197 to and 0.171 g. At the same time,. While the addition ofincorporating butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) to significantly decrease from lower around 0.003 until to 0.008 than control (K1). The highest and lowest swelling index values was were owned by K3 and K0 samples, respectively and the lowest swelling index values were belonging of the K0 sample. The swelling index values of wet noodles ranged around 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, . While 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 around from 18 to 19 -%.

Tensile strength, cooking loss, and swelling index of wet noodles was were clearly significantly influenced by participation the interaction of components in dough formation, the interaction amongnamely glutelin, gliadin, glucomannan, κ-carrageenan, and polyphenolic compounds, which resulted in a three-dimensional networkk k structure that determined the capability of resistance of the noodle strands being resistance to break and gel formation. κ-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 α-(1,3) and β-(1,4) glycosidic linkages [548,59] that can bind water molecule to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain β-1,4 linkage of D-glucose and D-mannose that can absorb water molecules around 200 times [5560] to form a strong gel that increases the viscosity and swelling index of the dough [5661]. Park and Baik [5762] stated that the gluten network formation affects the tensile strength of noodlesclaimed that tensile strength of

~~noodles is affected by gluten network formation~~. Huang et al. [535] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of ~~the~~ this hydrocolloid's strong water-binding capacity ~~of this hydrocolloid is very strong~~. Cui et al. [501] claimed that konjac glucomannan ~~does~~ not only stabilizes the structure of gluten network but also reacts with free water molecules to form a more stable ~~of a~~ three-dimensional networking structure, thus ~~holding~~ maintaining ~~the~~ dough's rheological and tensile properties ~~of dough~~.

The increas~~ing of~~ed swelling index of dough is caused by the capability of glucomannan to reduce the pore size and increase the pore numbers with uniform size [5863]. 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 [5964]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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 [59,6064-66]. The s~~S~~tability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the ~~dough of~~ wet noodle dough~~s~~ that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al. [27] and Widyawati et al. [15] 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 π-π stacking. The phenolic compounds of butterfly pea extract ~~were~~ interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt ~~a~~ the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfphide bridges to form of thiols radicals [6065,66]. These compounds can form complexes with protein and hydrocolloids, leading to structural and functional changes and influencinge gel formation thrrough aggregation formation and disulfide disulphide bridges breakdown [26,27,617].

The cColor of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction between the composite flour and butterfly pea extract (p≤0.05). The *L**, *a**, *b**, *C*, and °*h* increased with increasing the the ratio of composite flour ratio and the concentration of butterfly pea extract. Most of the color parameters values were lower than the the control samples (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas the an increaseding of amount of butterfly pea extract changed all color parameters. The ranging of *L**, *a**, *b**, *C*, and °*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 grew intensified with going upa higher the κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The cChroma and hue of wet noodles decreased with increasing of κ-carrageenan proportion from T0 until T15, and then increased at T30. K2T30 treatment had the strongest blue color compared with the other treatments (p≤0.05). The presence of κ-carrageenan in composite flour also supported the water--holding capacity of wet noodles that influenced color. κK-carrageenan was synergized with glucomannan to produce a strong , stable network that involved sulfhydryl groups. Masakuni Tako and Konishi [628] reported that κ-carrageenan is capable to associatecan associate making 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 very exceptionally complicated because theydue to the involved polar and non-polar functional groups and many kinds of interaction ~~of~~ between them. These ~~were~~ influenced the water content and water activity of the wet noodles, which~~s that~~ ~~were~~ impacted the wet noodle color. Another possible~~The other~~ cause that affects wet noodles' color profile ~~of wet noodles was~~is anthocyanin pigment from the butterfly pea extract. Gamage et al.[6~~3~~9] reported that the anthocyanin pigment of butterfly pea is delph~~f~~inidin-3-glucoside and ~~having~~ has a blue color. Increasing butterfly pea ~~of~~ extract concentration ~~declined~~ lowered the lightness, redness, yellowness, and ~~and~~ chroma and also ~~as well as~~ changed the hue color from yellow to ~~be~~ green- ~~until~~ 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.[64~~70~~] ~~and Padmawati et al.[71]~~ also found~~ed~~ similarities~~y~~ ~~of~~ in their research. Anthocyanin pigment of butterfly pea extract can ~~be~~ interact~~ed~~ with the color of stinky lily and κ-carrageenan, impacting the~~ed~~ color change of wet noodles. Thus, the sample T0 ~~is~~ was yellow ~~color~~, T15 ~~is~~ was green, ~~color~~ and T30 ~~is~~ was blue ~~color~~. Color intensity showed as chroma values of yellow values increased along with the higher proportion of κ-carrageenan at the same concentration of butterfly pea extract.~~,~~ ~~but~~ However, the higher concentration of butterfly pea extract ~~declined~~ lessened the green and blue colors of wet noodles ~~at~~ made using the~~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 processes~~ses~~. Widyawati et al.[28] reported that the bioactive compounds in pluchea extract ~~can~~ could change the wet noodle color because of the discoloration of pigment during cooking. K2T30 was wet noodles ~~having~~ exhibiting the strongest blue color due to different interactions of between anthocyanin and hydrocolloid compounds, especially κ-carrageenan, that were capable to reduce could reduce the intensity of blue color or chroma values.

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

The results of TPC, TFC, and TAC were are shown in Fig. 5. The TPC and TFC of wet noodles were significantly influenced by the interaction between two parameters: of the ratio of composite flour and the concentration of butterfly pea extracts ($p \leq 0.05$). The highest proportion of κ-carrageenan and butterfly pea extract resulted in the highest TPC and TFC. The K2T30 had the highest TPC and TFC as of about ~ 207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. While Tthe TAC of wet noodles was only influenced by the concentration of butterfly pea extract, and the increase in extract addition leading led to an increase in TAC. The extract substitution addition at in T30 was obtainedpossessed a TAC aboutof about 3.92±0.18 mg delfidine-3-glucoside/kg dried noodles of TAC. Based onIn addition, based on Pearson correlation assessment, there was a strong, positive correlation Pearson correlation, between the TPC of wet noodles was strong and positive correlated withand the TFC at T0 treatment (r= 0.955), T15 treatment (r=0.946), and T30 treatments (r=0.765). In contrast, , while a weak, positive correlation was observed between the TPC of samples was weak and positive correlated withand the TAC at T0 treatment (r=0.153) and T30 treatments (r=0.067), except the samples at 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 dDominant anthocyanin pigment from butterfly pea extract is delphinidin [6572], around 2.41 mg/g samples [6673] that has free more acyl groups and aglycone structure [6774] and that can be used as a natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is a potential as antioxidant agent through the free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling [6875,76]. Nevertheless, butterfly pea extract is also composeds of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6”-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose) [20,21], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids [6774], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutenene [6977,78], that contribute to have the antioxidant activity [18,6978]. *Clitoria ternatea* shows to exhibit potential as antioxidant activity based on an 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^{2+} reducing power assays [6978]. 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. [7079] claimed that glucomannan contained in stinky lily has hydroxyl groups that can be reacted with Folin Ciocalteus’s phenol reagent. Devaraj et al. [7180] reported that 3,5-acetyltalbulin is a flavonoid compounds in glucomannan that can be bound complexesform a complex with $AlCl_3$.

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 Fig. 5. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ($p\leq0.05$). The noodles ~~had~~ exhibited DPPH values ranging from 3 to 48 mg GAE/kg dried noodles. ~~The~~ Several wet noodle samples,~~s~~ including the composite flour of K0 and K1 and without ~~of~~ 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 c~~C~~orrelated coefficient values (r) between TPC and AOA at T0, T15, and T30 treatments were 0.893, 0.815, and 0.883, respectively. ~~Whereas~~ Meanwhile, the r valuess~~s~~ between TFC and DPPH at T0, T15, and T30 treatments ~~were~~ were 0.883, ~~at T15 treatment were~~ 0.739, and ~~at T30 treatment were~~ 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 i~~I~~nteraction among glucomannan, phenolic compounds, amylose, gliadin, and glutelin in the dough of wet noodles determined the number and position of free hydroxyl groups ~~of them~~ that influenced the TPC, TFC, and DPPH. Widyawati et al.[46] ~~said~~ 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 κ-carrageenan proportion and butterfly pea extract for ~~significantly~~ up to 18 and 2 % (w/w) of stinky lily flour ~~glucomannan~~ and κ-carrageenan and 15 % (w/w) of extract. However, ~~, but~~ the ~~using~~ use of 17 and 3 % (w/w) of stinky lily flour ~~glucomannan~~ and κ-carrageenan and 30 % (w/w) of extract showed a significant decrease. ~~This~~ The results show~~ed~~ that the use of stinky lily flour and k-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~~5%~~). FRAP was used to measure the capability of antioxidant compounds to reduce Fe^{3+} ions to be Fe^{2+} ions. The FRAP capability of wet noodles was lower than DPPH, which ranged from~~ing~~ 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without κ-carrageenan and butterfly pea extracts (K0T0) had the lowest FRAP, while the samples containing composite flour K2 with 30 % of butterfly pea extract~~s 30%~~ (K2T30) had the highest FRAP. The Pearson correlation values showed that TPC ~~dan~~ and TFC at T0 and T30 treatments had strong and positive correlations~~ed~~ to FRAP activity, but T15 treatment possessed a weak and positive correlation (Table 7). The c~~C~~orrelation coefficient (r) values of TAC at T0 treatment was weak ~~and~~ with positive ~~correlated~~ correlation to FRAP samples, but the r values at T15 and T30 treatments ~~owned~~ showed weak ~~and~~ negative correlations (Table 3). The obtained correlation between DPPH and FRAP activities ~~was obtained~~elucidates that the DPPH method was highly correlated with the FRAP method at T0 and T30 treatments and ~~lowly~~ weakly correlated at T15 treatment (Table 3). ~~Based on~~The DPPH and FRAP methods showed the ~~that~~ capability of wet noodles to scavenge free radical was higher than them to reduce ferric ion. It proved that the bioactive compounds of wet noodles ~~were~~ are more potential as free radical scavengers or hydrogen donors than as ~~donor~~ electron donors. Compounds that have ~~capability to~~ reducing power can act as primary and secondary antioxidants[72~~81,82~~]. Poli et al.[7~~8~~3] ~~said~~ stated that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[74~~84~~] claimed that a secondary antioxidant is a natural antioxidant that has capability to reduce ferric ion (FRAP). Based on AOA assay results, the results showed that phenolic compounds indicated a strong and positive correlation with flavonoid compounds, as because of flavonoids they are the major phenolic compounds that are potential as antioxidant activities agents pass through their ability to scavengehighly effective scavenger of various free radicals. The effectivity of flavonoid compounds to 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 [7585-87]. Previous studies have proven that TPC and TFC exhibit significantly contribute or to scavenge free radicals [7688-90]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al. [7689] stated that TPC and anthocyanins have a significant and positive correlation with AOA, but anthocyanins were insignificantly correlated with AOA. Different structure of anthocyanins in samples determines AOA. —Moreover, the polymerization or complexion of Polymer aanthocyanins or anthocyanin complexed with other molecules assign also determines their capability as of them to electron or hydrogen donors. Martin et al. [7791] informed that the anthocyanins are the major groups of phenolic pigments that are an essentialwhere their antioxidant activity greatly depends on a the steric hindrance of their chemical structure, such as number and position of hydroxyl groups and the conjugated doubles bonds, as well as the presence of electron 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 involved as reducing power agents that contributed them to donordonating electrons. Paddayappa et al. [7282] reported that the phenolic compounds are capable to of embroilinged redox activities with an action as hydrogen donor and reducing agents. The weakly relationship between TPC, or 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 ~~method~~test results~~,~~ showed that composite flour and butterfly pea extract additions significantly influenced color, aroma, taste, and texture preferences (p≤ 0.05) (Table 4).~~ ~~ 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. ~~The using~~Incorporating ~~of~~ butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensit~~y~~ies of wet noodle~~'s~~ color that resulted in color degradation from yellow, green, ~~until~~ to blue color, ~~impacted~~ impacting the color preference of wet noodles. Nugroho et al.~~ ~~[48] also informed that the addition of butterfly pea ~~extract~~extracts ~~upgraded~~ elevated the preference of panelists ~~to~~ for dried noodles. The a~~A~~roma of wet noodles was also affected by two parameters of treatments, where the results showed that the higher proportion of stinky lily caused ~~the~~ the wet noodles to have a stronger, musty smell~~ of wet noodles~~. Utami et al. [~~78~~92] claimed that oxalic acid ~~of~~ contained in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan ~~can~~ could reduce the proportion of stink lily flour, thereby increasing the panelists'~~'s~~ preference for wet noodle aroma. Sumartini and Putri~~ ~~[~~79~~93] ~~informed~~ noted that panelists ~~is~~ preferred~~more like~~ noodles substituted ~~the~~ with a higher κ-carrageenan.~~ ~~ ~~Kurniadi et al. [94] and~~ Widyawati et al.~~ ~~[15] ~~said~~ also proved that κ-carrageenan is an odorless material ~~which~~ that ~~doesn't~~ does not ~~result~~ affect the aroma of wet noodles.~~ ~~ Neda et al. [~~68~~77] 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.~~ ~~[~~80~~71] ~~informed~~ revealed that ~~they~~ butterfly pea extract ~~can~~ could ~~gave~~ give a sweet~~y~~ and sharp aroma. The panelists' taste preference ~~of panelist~~ to wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin [81~~95~~], due to Maillard reaction ~~of~~ during stinky lily flour processing. Nevertheless, using ~~of~~ butterfly pea extract at a higher concentration ~~of~~ in wet noodles increased the bitter taste, which is contributed by ~~related to~~ tannin compounds in this flower, as has been found ~~, this is supported~~ by ~~Hasby et al. [96] and~~ Handayani and Kumalasari [82~~97~~]. The e~~E~~ffect of composite flour proportion and butterfly pea extract addition also appeared to the texture preference of wet noodles. Panelists ~~was likely~~preferred wet noodles that ~~was~~ did not break up easily, which was ~~that~~ the K3T0 sample, as the treatment resulted in~~s~~ ~~were~~ chewy and elastic wet noodles.~~,~~ T~~t~~h~~is was supp~~e results were also affected~~orted~~ 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, ~~break easy~~easy-to-break, and less chewy wet noodles [26,27,82,~~85,97~~] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel [83~~98~~]. Based on the index effectiveness test, the noodles ~~including~~ 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 ~~of~~ composite flour containing wheat flour, stinky lily flour, and κ-carrageenan and butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties ~~of wet noodles~~. Interaction among glutelin, gliadin, amylose, glucomannan, κ-carrageenan, and phenolic compounds ~~determined~~ affected ~~a~~ the three-dimensional network structure that impacted moisture content, water activity, tensile strength, color, cooking loss, ~~and~~ swelling index, bioactive content, antioxidant activity, and sensory properties of wet noodles. –The higher concentration of hydrocolloid addition caused ~~increasing~~ increased~~of~~ water content and swelling index and ~~decreasing~~ decreased~~of~~ water activity and cooking loss. In addition, incorporating~~Addition of~~ butterfly pea ~~extract~~extracts improved color, bioactive content, and antioxidant activity and ~~repaired~~ enhanced panelist preference ~~of~~ for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract ~~were able to increase~~ increased the functional value of resulting wet noodles.

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Conflict of Interest

The authors declare no conflict of interest

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Table 1. Formula of wet noodles

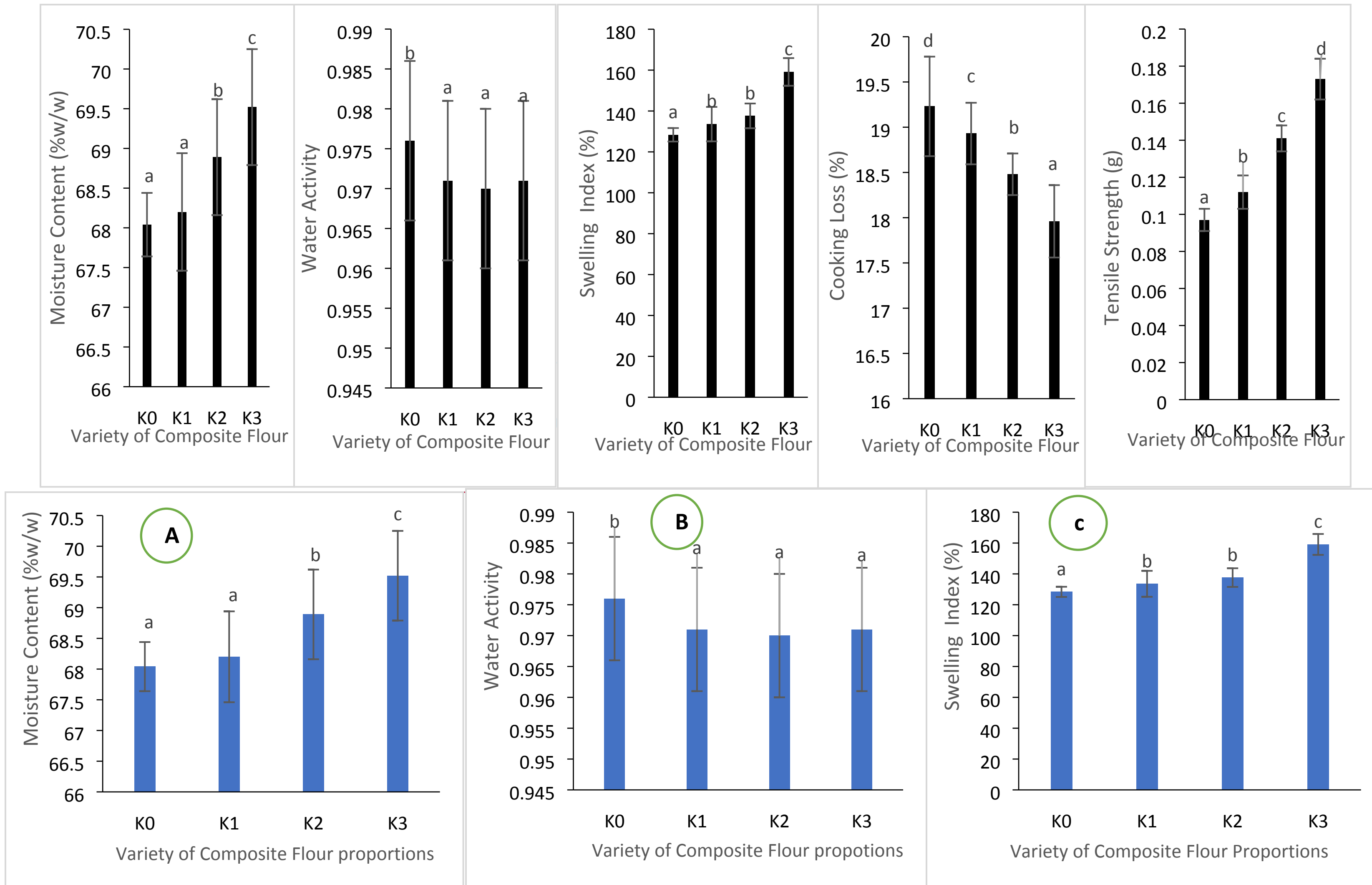
Treatment	Code	Ingredients				
		Salt (g)	Fresh whole Egg (g)	Water (mL)	Butterfly pea extract Solution (mL)	Composite flour (g)
1	K0T0	3	30	30	0	150
2	K0T15	3	30	0	30	150
3	K0T30	3	30	0	30	150
4	K1T0	3	30	30	0	150
5	K1T15	3	30	0	30	150
6	K1T30	3	30	0	30	150
7	K2T0	3	30	30	0	150
8	K2T15	3	30	0	30	150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

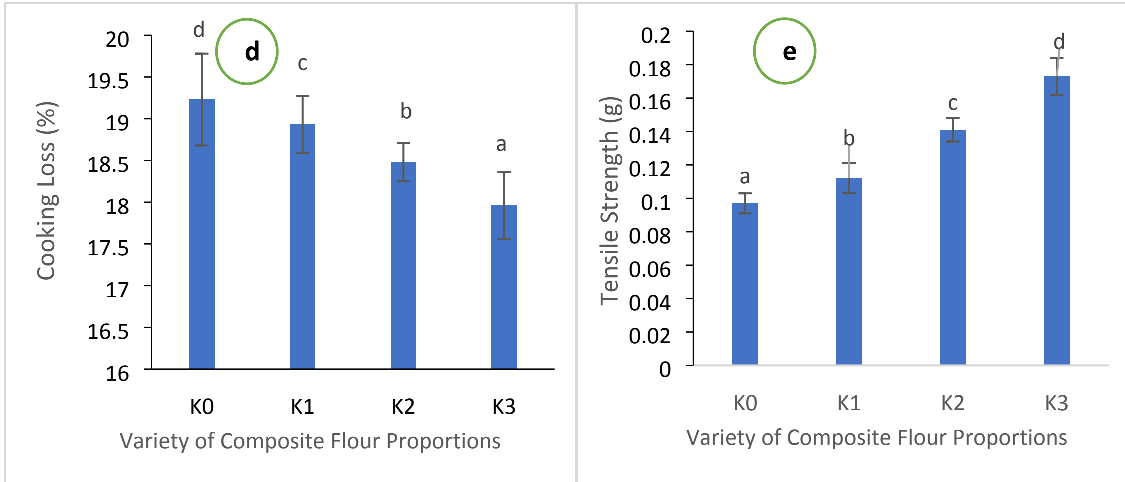
Note: K0 = wheat flour: stink lily flour: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-carrageenan = 80:17:3 (%w/w). T0 = concentration of the 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

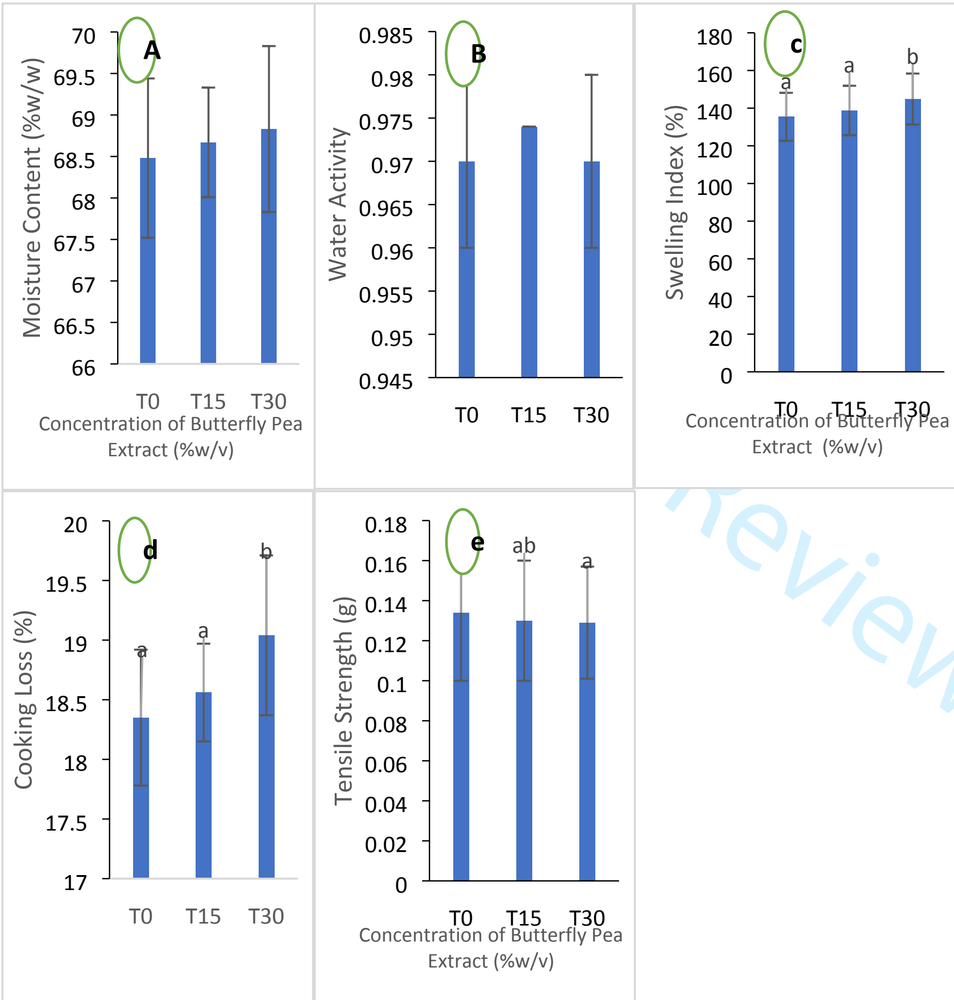
NB: No significant eEffect of interaction between composite flour and butterfly pea extract to quality properties of wet noodles. The results were presented as SD of means that were achieved by triplicate. All of data showed that no interaction of two parameters influenced quality properties of wet noodles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

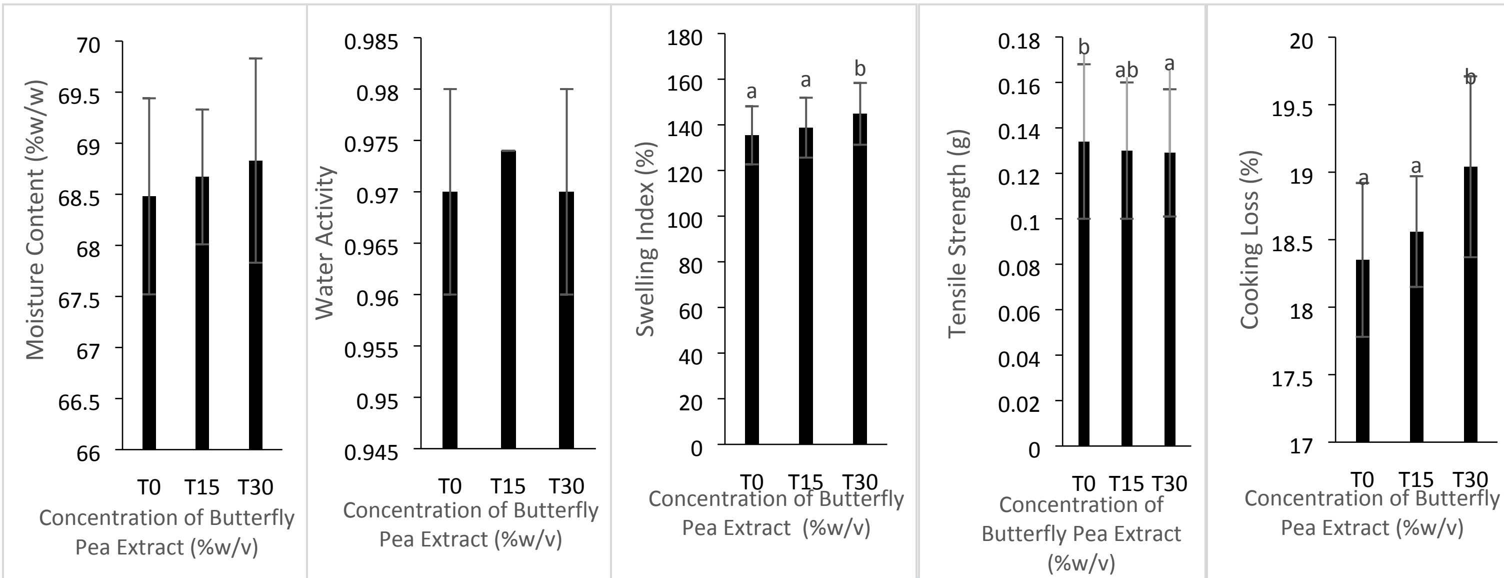

Moisture Content (%w/w)
Variety of Composite Flour
Water Activity
Variety of Composite Flour
Swelling Index (%)
Variety of Composite Flour
Cooking Loss (%)
Variety of Composite Flour
Tensile Strength (g)
Variety of Composite Flour
K0 K1 K2 K3
A
Moisture Content (%w/w)
Variety of Composite Flour proportions
B
Water Activity
Variety of Composite Flour propotions
c
Swelling Index (%)
Variety of Composite Flour Proportions



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

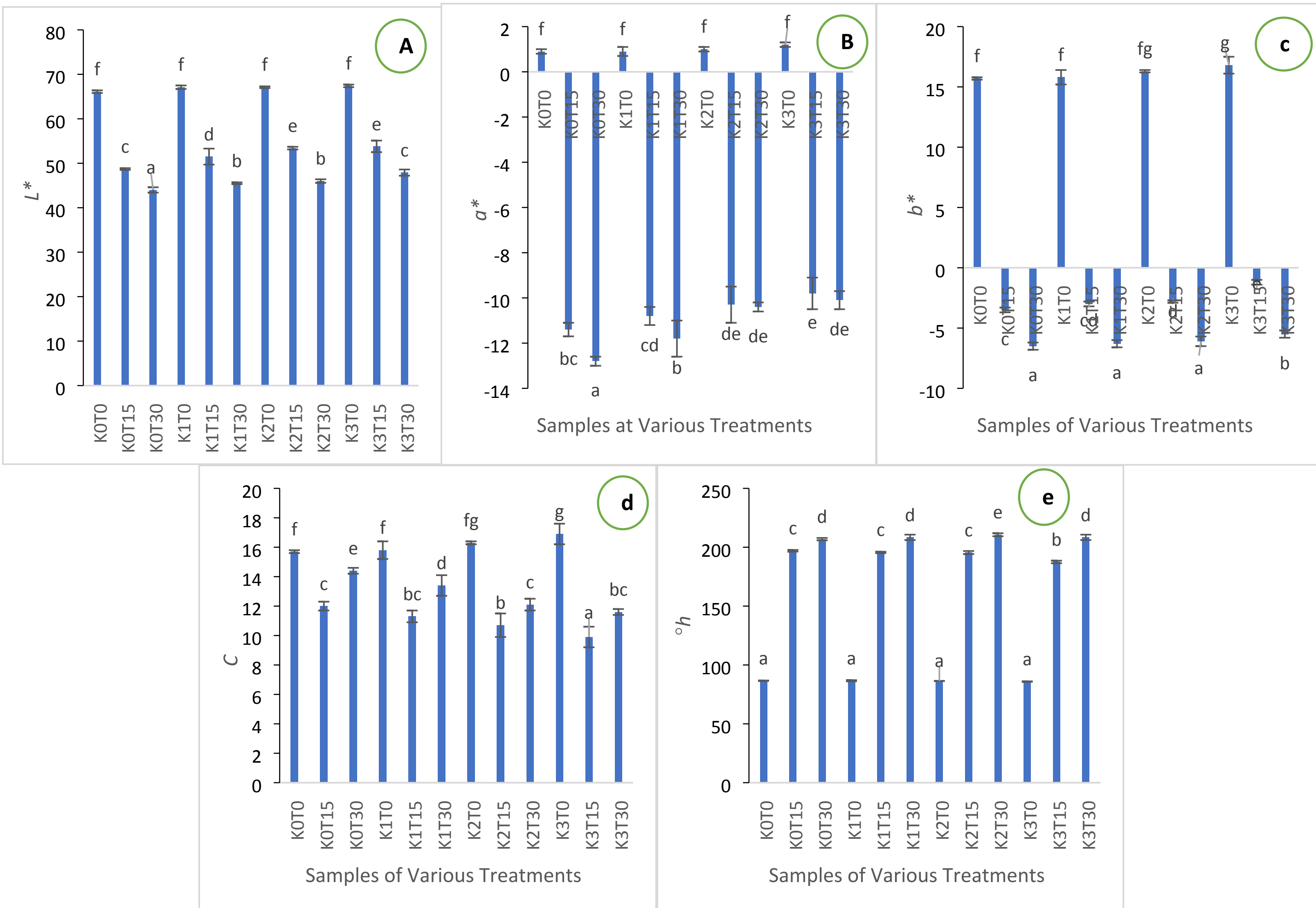
Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different, p ≤ 0.05~~5%~~.


A
70
69.5
69
68.5
68
67.5
67
66.5
66
Moisture Content (%w/w)
T0 T15 T30
Concentration of Butterfly Pea Extract (%w/v)
B
0.985
0.98
0.975
0.97
0.965
0.96
0.955
0.95
0.945
Water Activity
T0 T15 T30
c
180
160
140
120
100
80
60
40
20
0
Swelling Index (%)
a a b
T0 T15 T30
Concentration of Butterfly Pea Extract (%w/v)
d
20
19.5
19
18.5
18
17.5
17
Cooking Loss (%)
a a b
T0 T15 T30
e
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
Tensile Strength (g)
ab a
T0 T15 T30
Concentration of Butterfly Pea Extract (%w/v)



(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~~5%~~.


A
L*
B
a*
Samples at Various Treatments
c
b*
Samples of Various Treatments
d
C
Samples of Various Treatments
e
°h
Samples of Various Treatments
K0T0 K0T15 K0T30 K1T0 K1T15 K1T30 K2T0 K2T15 K2T30 K3T0 K3T15 K3T30

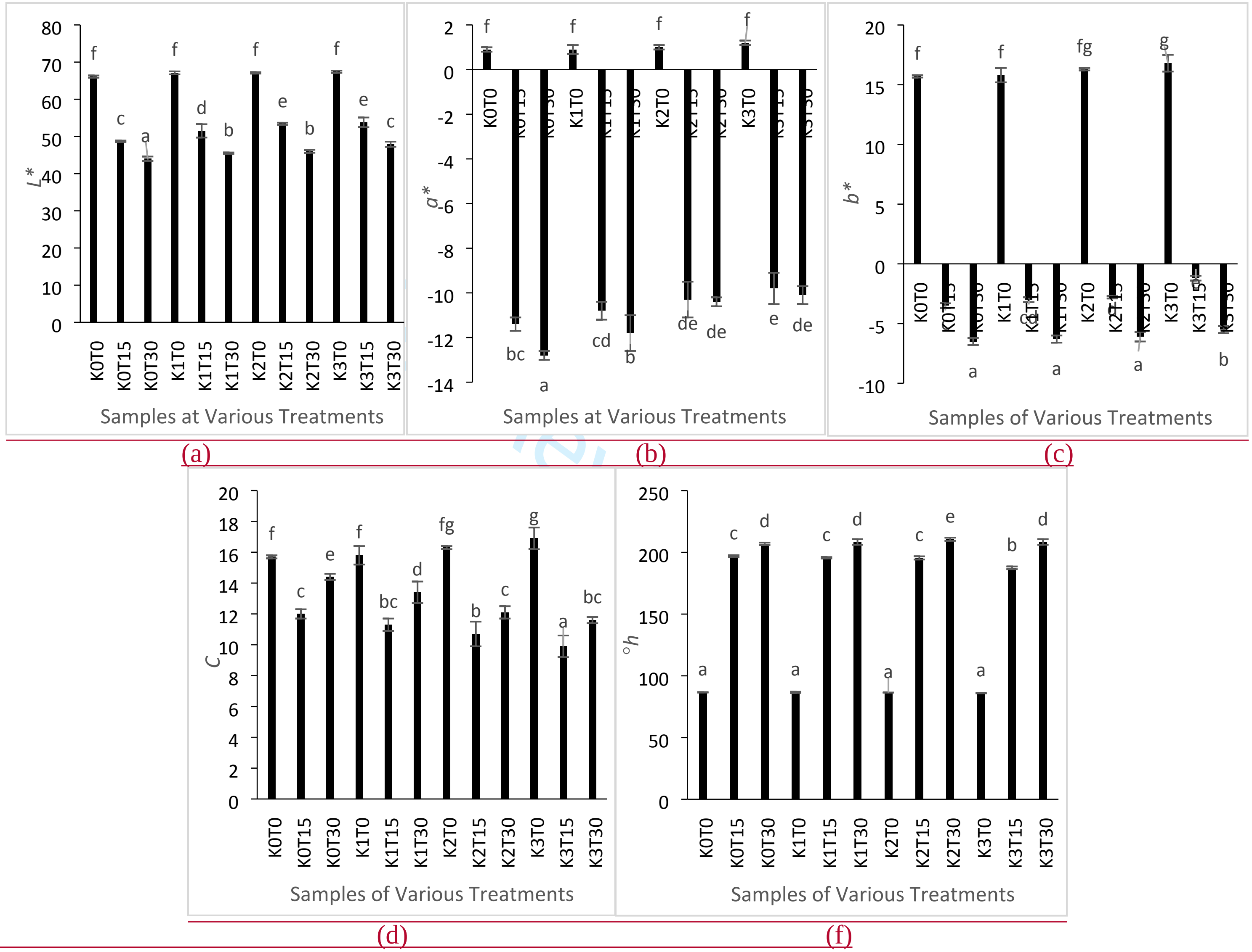


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different, $p \leq 0.05$~~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, $p \leq 5\%$.

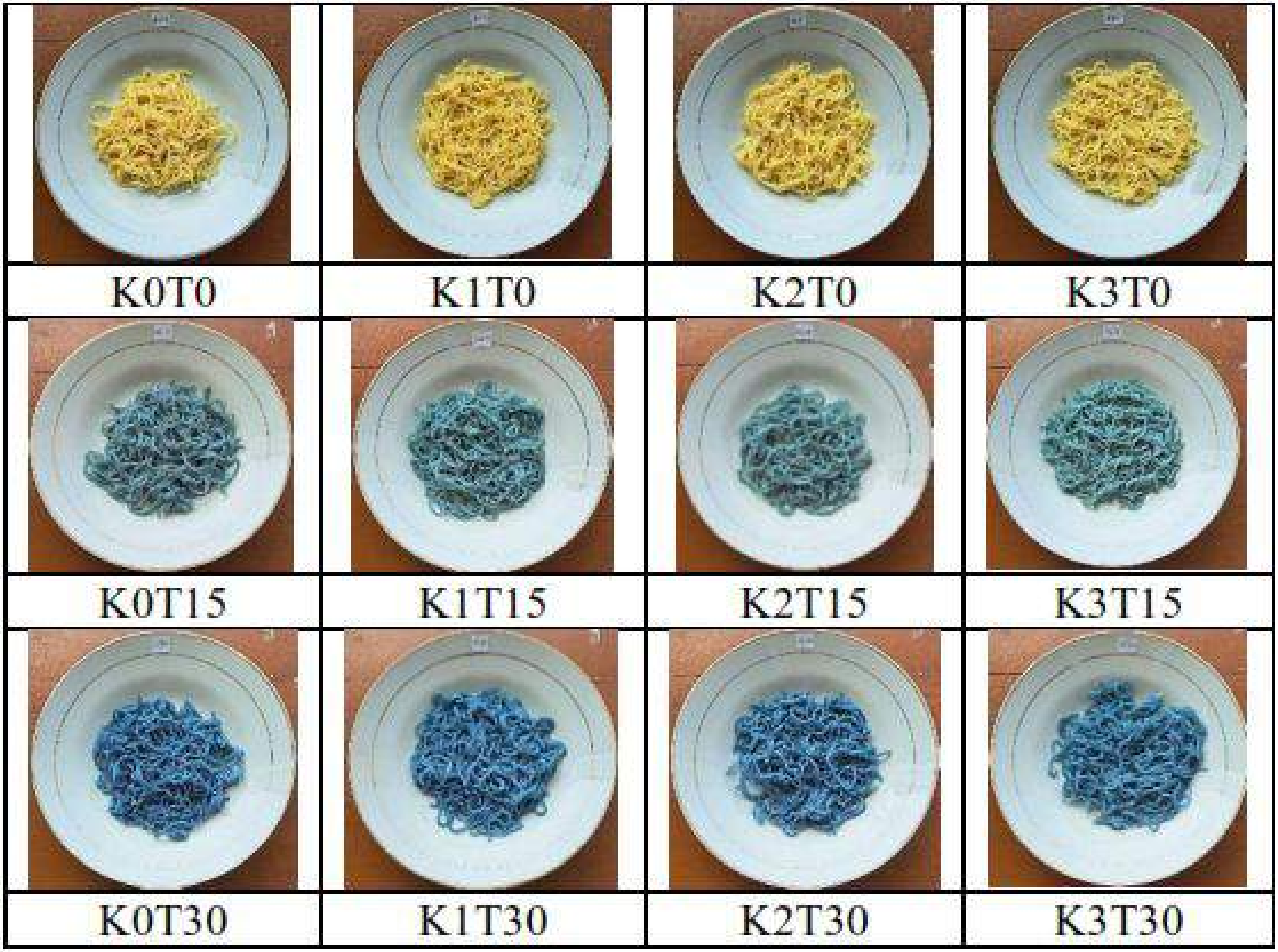
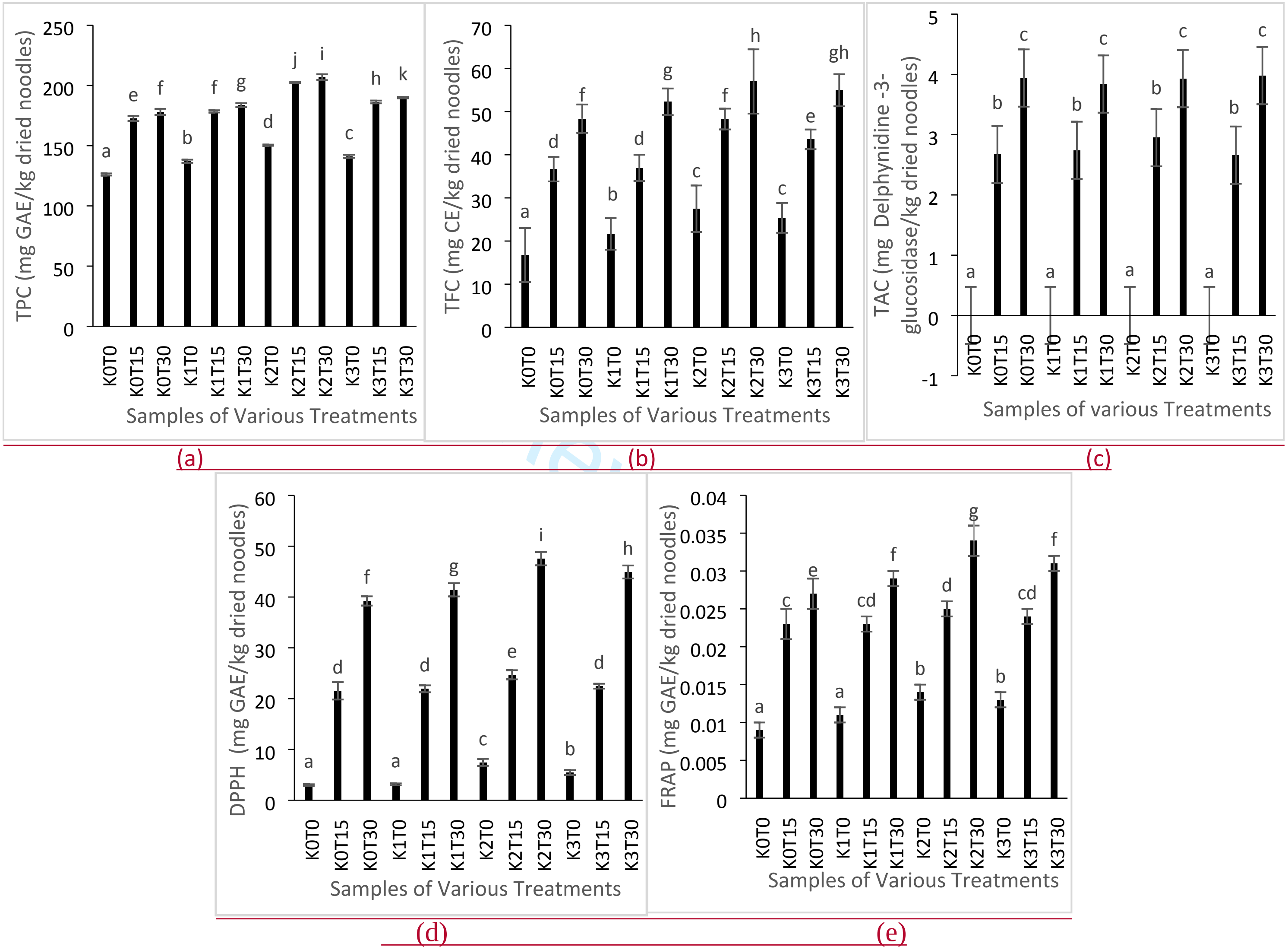
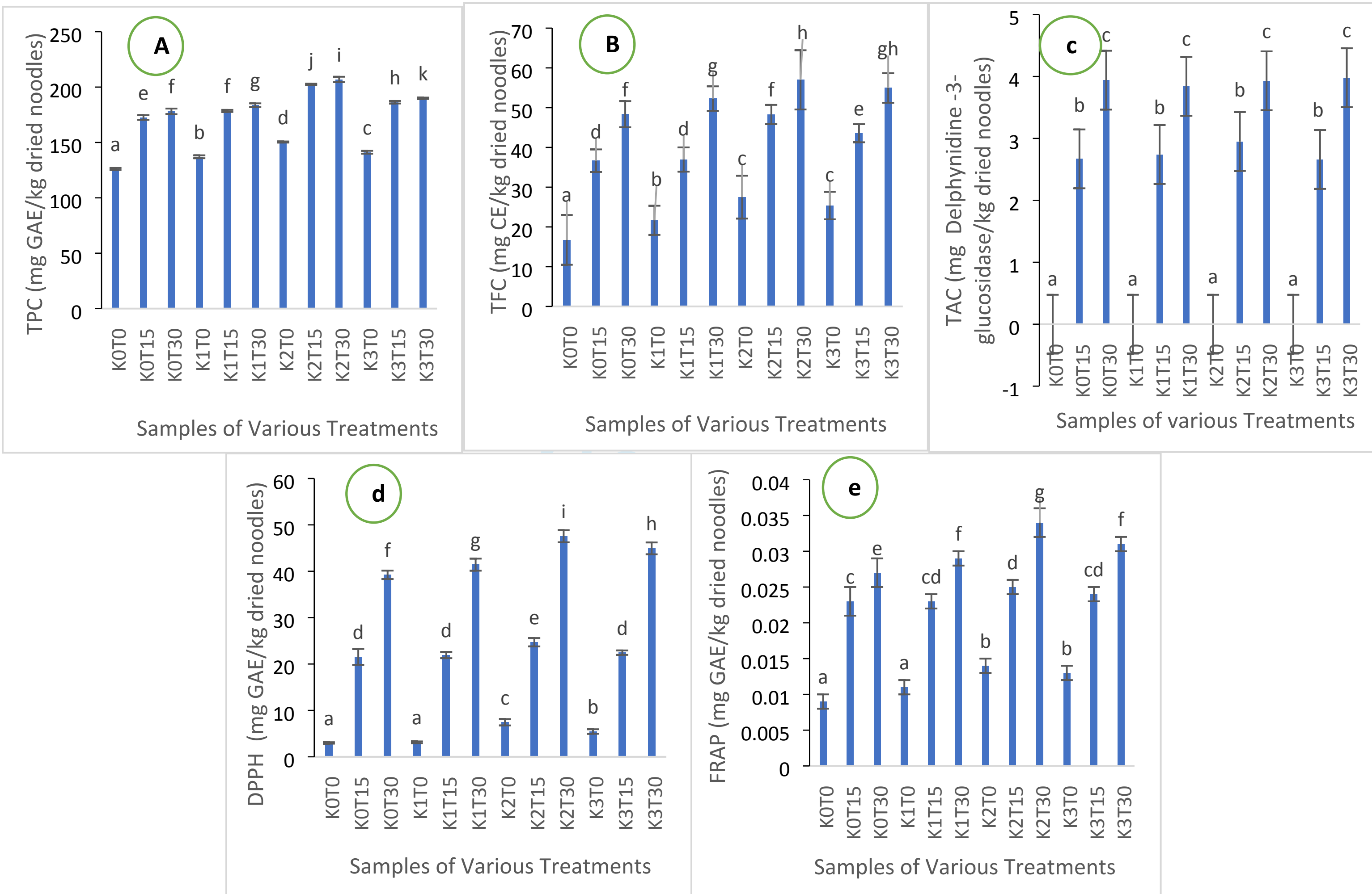


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract


TPC (mg GAE/kg dried noodles)
Samples of Various Treatments
(a)
TFC (mg CE/kg dried noodles)
Samples of Various Treatments
(b)
TAC (mg Delphynidine -3-glucosidase/kg dried noodles)
Samples of various Treatments
(c)
DPPH (mg GAE/kg dried noodles)
Samples of Various Treatments
(d)
FRAP (mg GAE/kg dried noodles)
Samples of Various Treatments
(e)
K0T0
K0T15
K0T30
K1T0
K1T15
K1T30
K2T0
K2T15
K2T30
K3T0
K3T15
K3T30



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

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, $p \le$ 0.05~~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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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: 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

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

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, $p \leq 0.05$.

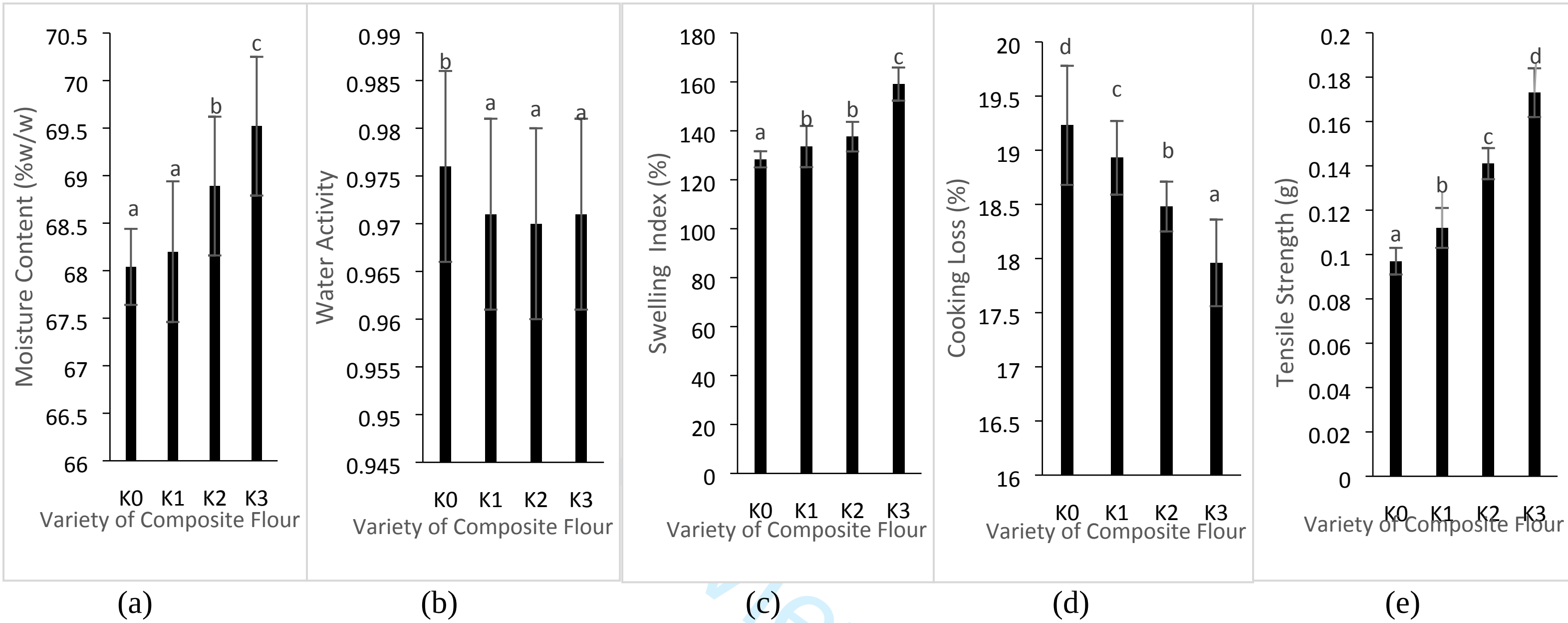


Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets)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

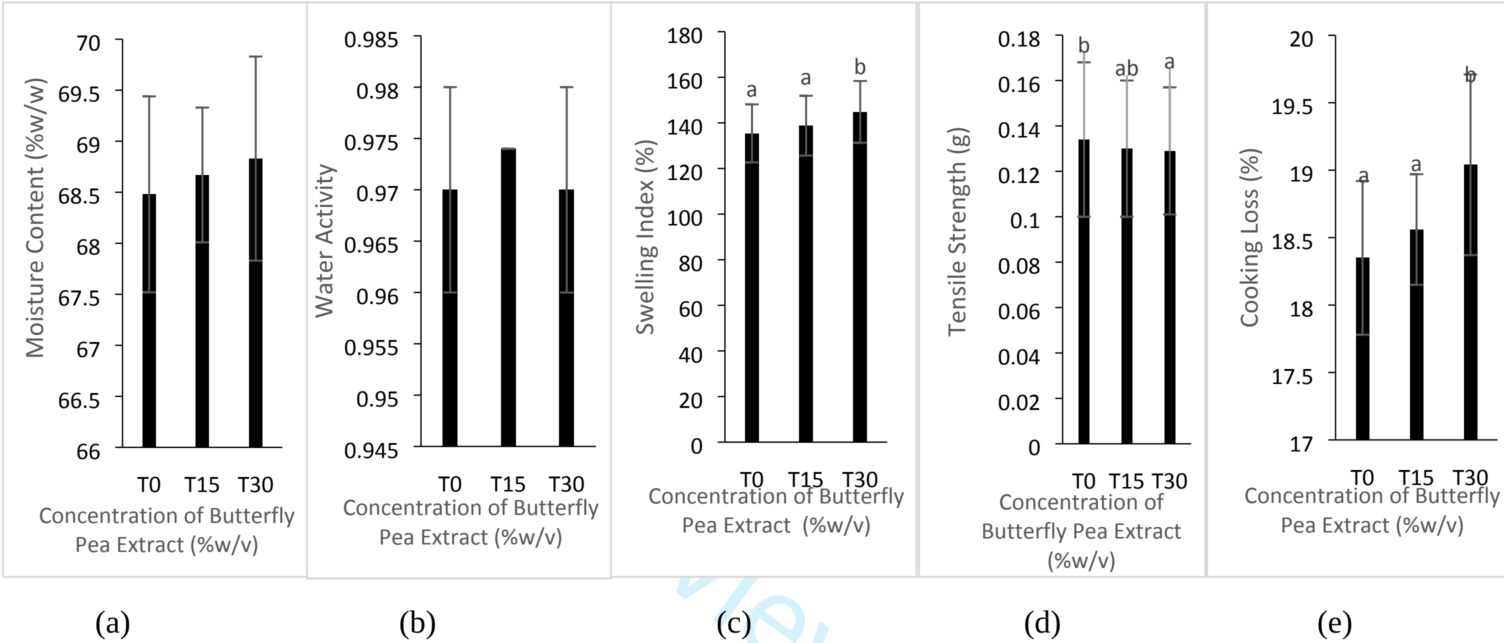


Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

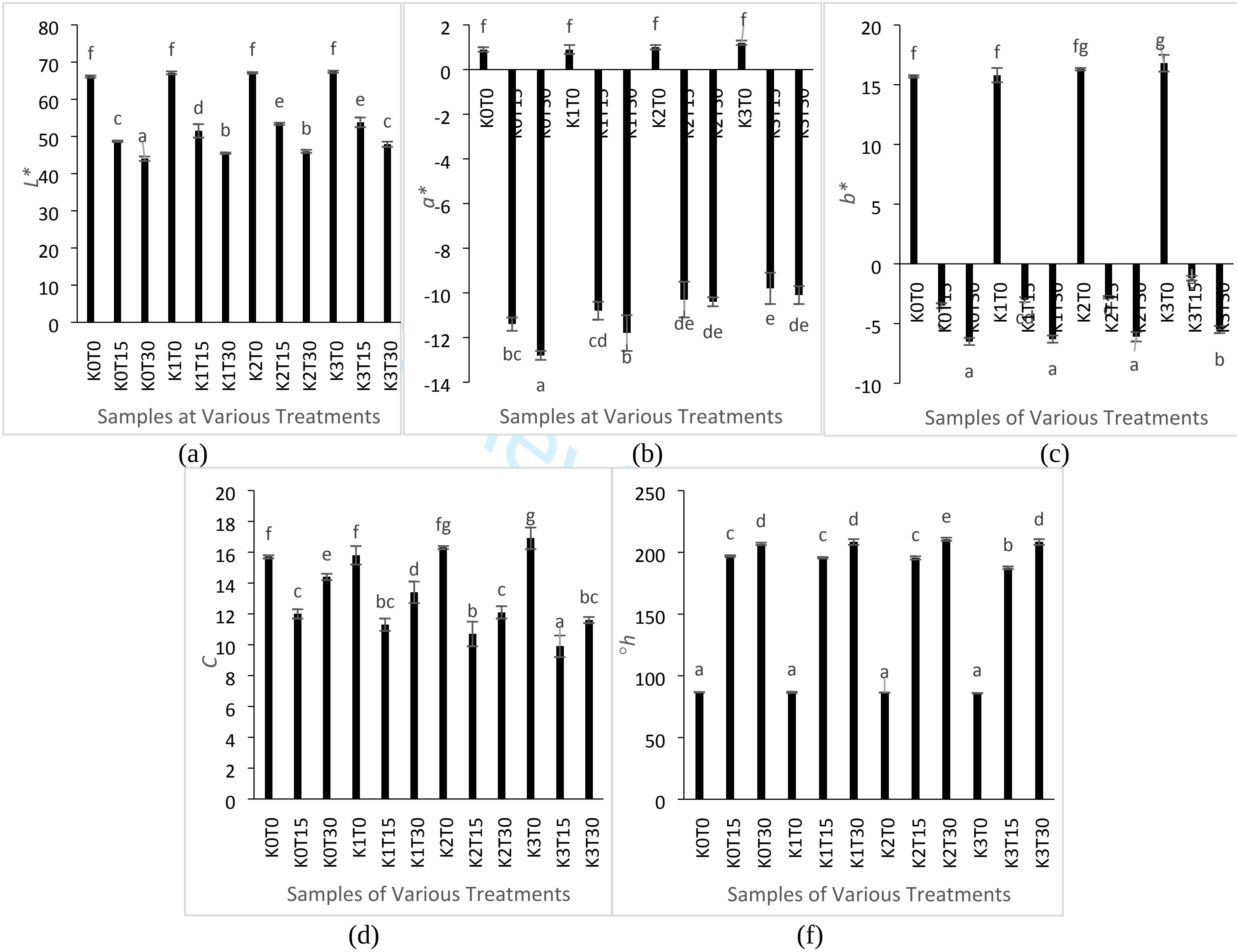


Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

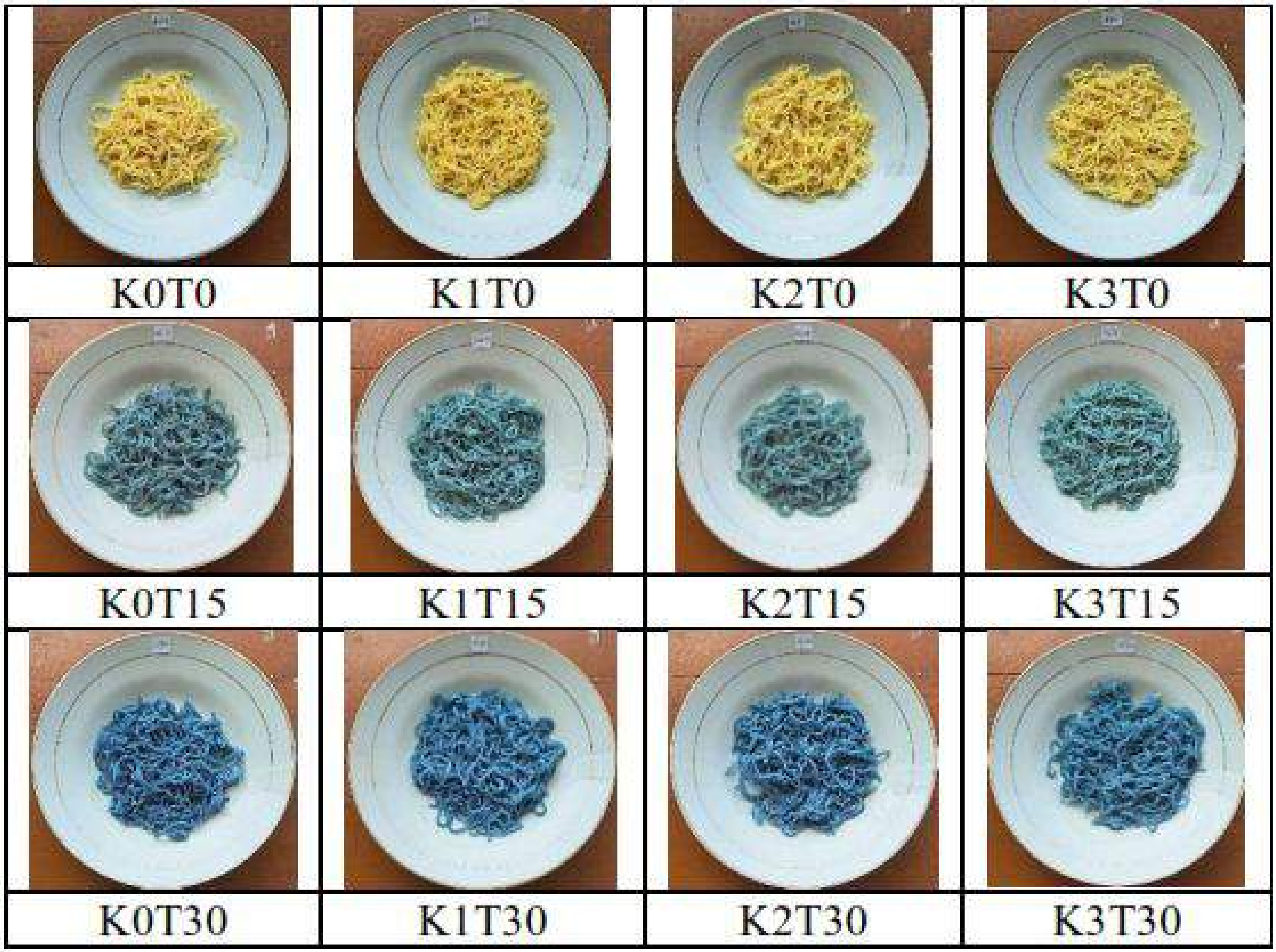


Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

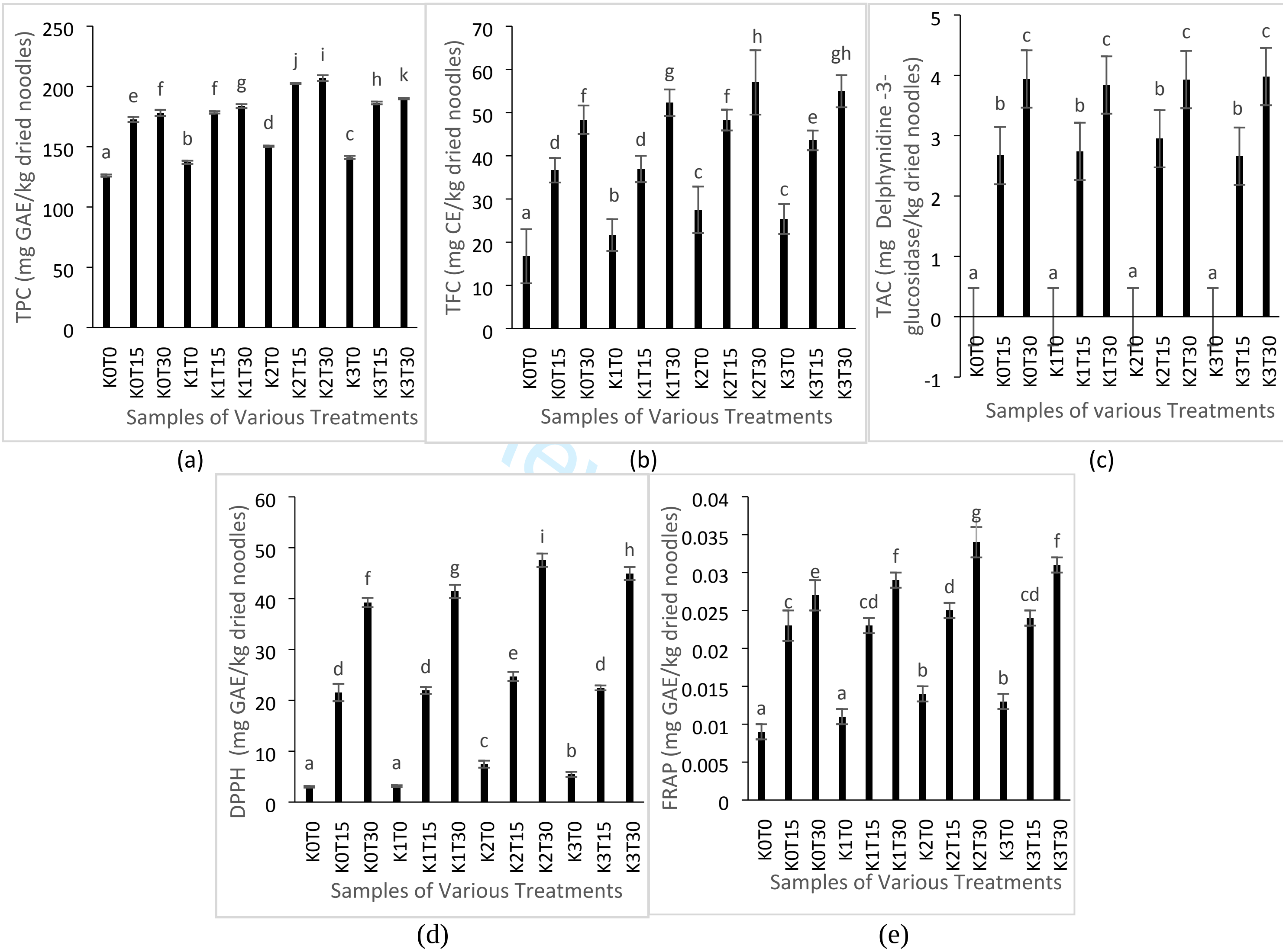


Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

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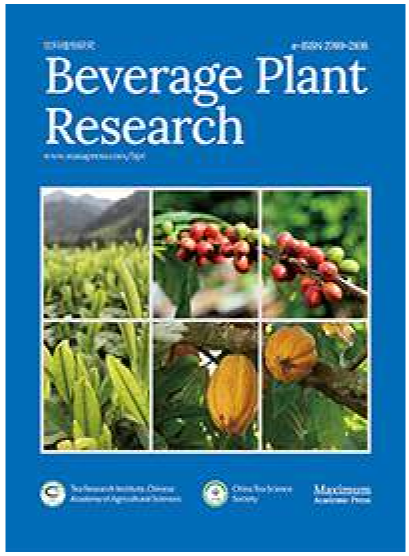

Effect of butterfly pea (Clitoria ternatea) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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

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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Abstract

The improving of wet noodles qualities, sensory and functional properties were done by using the composite flour base added with the butterfly pea flower extract. The composite flour of wheat flour, stink lily flour and κ-carrageenan at various ratio of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3(K3) (% w/w) was used with the concentration of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The research employed randomized block design with 2 factors, namely the composite flour and the concentration of butterfly pea flower extract that resulted 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 were significantly affected the color, sensory properties, bioactive compounds, and antioxidant activity of wet noodles. However, each factor had significant influenced of the physical properties from wet noodles, such as moisture content, water activity, tensile strength, swelling index and cooking loss. The using of κ-carrageenan up to 3% (w/w) in composite flour 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-κ-carrageenan at ratio of 80:17:3 (% w/w) was the best consumer acceptance based on hedonic sensory score.

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

Introduction

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

Previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional values of noodles by increasing the biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and prolong gastric emptying time [8,9]. However, adding of stink lily flour in base noodles flour had limited on elasticity and tensile strength of wet noodles [10,11]. Then, the κ-carrageenan was added to improve the texture properties of wet noodles. Those components were a collaborates with glucomannan to form cross linking with glutenin and gliadin by intern and intra-molecular bonds leading to improving of noodle texture [12-14]. Widyawati et al. [15] explained that using of the composite flour consisted of wheat flour, stink lily flour and κ-carrageenan can look up swelling index, total phenolic content (TPC), total flavonoid content (TFC) and DPPH free radical scavenging activity that influences an effectivity of bioactive compounds on composite flour as antioxidant of wet noodles. Therefore, addition of the other ingredient enriched phenolic compounds is done to increase functional values of composite flour as antioxidant. Czajkowska–González et al. [16] informed that elaborate of natural antioxidant sources enriched phenolic compounds can improve functional values of bread. Widyawati et al. [15] has added pluchea extract to increase TPC, TFC and DPPH free radical scavenging activity of wet noodles, but the weakness of wet noodle color is not attractive that it is necessary to look for other ingredients, one of which is butterfly pea flower.

Butterfly pea (*Clitoria ternatea)* is an herb plant, Fabaceae family, having various color flower, such as purple, blue, pink, and white [17]. This flower has phytochemical compounds which are benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides [20,21]. Anthocyanins of the butterfly pea flower has been used as natural color in many food products [22,23], one of them is wet noodles [24,25]. The phytochemical compounds, especially phenolic compounds, can influence the interaction among gluten, amylose and amylopectin depend on partition coefficients, keto-groups, double bonds (in the side chains), and the benzene ring [26]. This interaction involves covalent and non-covalent bonds of them which were influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility [27]. Previous study has proven that the use of phenolic compounds from plant extract, such as pluchea leaf [15,28], gendarussa leaf (*Justicia gendarussa* Burm.F.) [29], carrot and beetroot [30], kelakai leaf [31] establishes the quality, bioactive compounds, antioxidant activity and sensory properties of wet noodles. Shiau et al. [25] has utilized natural color of butterfly pea flower extract to make wet noodles base wheat flour that results the higher total anthocyanin, polyphenol, DPPH scavenging activity and reducing power than the control samples and the use of this extract can improve color preference and reduce the cutting force, tensile strength, and extensibility of cooked noodles. 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 κ-carrageenan) has not been studied. Therefore, the study was conducted to decide the effect of composite flour and butterfly pea flower extract to quality, bioactive content, antioxidant activity, and sensory properties of wet noodles.

Materials and Methods

Raw materials and preparation

Butterfly pea flower was obtained from Penjaringan Sari garden, Wonorejo, Rungkut, Surabaya, Indonesia. The flower was sorted, washed, dried by open sunlight, powdered using blender (Philips HR2116, PT Philips, Netherlands) for 3 min, 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 hot water extraction at 95^{o}C for 3 min to get three concentrations of butterfly pea extract of 0 (T1), 15 (T15), and 30 (T30) (% w/v). The three composite flours proportion were prepared with a mixing of wheat flour (Cakra Kembar, PT Bogasari Sukses Makmur, Indonesia), stink lily flour (PT Rezka Nayatama, Sekotong, Lombok Barat, Indonesia), and κ-carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratio of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

Chemical and reagents

The 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). Distillated water was purchased by local market (PT Aqua Surabaya, Surabaya, Indonesia).

Wet noodles preparation

Wet Noodles were prepared based on the modified formula of Panjaitan et al. [11] 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 concentration. The salt, water, fresh whole egg was then added and kneaded to make dough by using a mixer machine (Oxone Master Series 600 Standing Mixer OX 851, China). The dough was sheeted and cut via rollers using cutting blades (Oxone OX355AT, China). Wet noodles were sprinkled with tapioca flour before heated in boiled water (100^{o}C) with a ratio of raw noodles /water at 1:4 w/v for 2 min. Cooked wet noodles were coated with palm oil before subjected to measure the quality and sensory properties but the samples without cooking and oil coating were used to analyze the bioactive compounds and antioxidant activity.

Extraction of bioactive compounds of wet noodles

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

Moisture content analysis

Water content of cooked wet noodles was analyzed based on thermogravimetry method[32]. 1 g samples were weighed in weighing bottle and heated by drying oven at 105-110°C for 1 h, then samples were weighed and measured moisture content after weight of samples was constant. Moisture content is calculated based on the difference in sample weight before and after a constant weight is reached divided by the initial sample weight expressed as a percentage of wet base.

Water activity analysis

Water activity of cooked wet noodles was analyzed using Aw-meter (Water Activity Hygropalm HP23 Aw a set 40 Rotronic, Swiss). 10 g samples were weighed and entered in Aw meter chamber, analyzed and data recorded [33].

Tensile strength analysis

Tensile strength is essential parameter that measures extensibility of cooked wet noodles[39]. 20 cm samples were measured tensile strength using texture analyzer that be equipped by Texture Exponent Lite Program and used noodle tensile rig probe (TA-XT Plus, Stable Microsystem, UK). The noodle tensile rig was set to be pre-set speed, test speed, post-test speed 1 mm/s, 3 mm, 10 mm/s, respectively. Distance, time, and trigger force were used 100 mm, 5 sec and 5 g, respectively.

Color analysis

10 g cooked wet noodles were weighed in chamber and analyzed color using color rider (Konica Minolta CR 20, Japan) based on the method of Harijati et al.[35]. Parameter measurement was lightness (*L**), redness (*a**), yellowness (*b**), Hue (°*h*), and chroma (C). *L** value is ranged 0-100 that expressed brightness, *a** value shows red color which has an interval between -80 - +100.

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

Swelling index analysis

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

Cooking loss analysis

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

Total phenolic content analysis

Total phenolic content of wet noodles was determined using Folin-Ciocalteu's phenol reagent based on the modified method of Eyele et al. [42]. 50 µL of extract was added 1 mL of 10% Folin-Ciocalteu's phenol reagent in 10 mL volumetric flask, shaken and incubated for 5 min. Then, 2 mL of 7.5 % Na_2CO_3 was added and the volume was adjusted to 10 mL with distillated water. Solution was measured absorbance at λ 760 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The standard reference was used gallic acid and the result was expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Total flavonoid content analysis

Total flavonoid content was analyzed on the modified method using Li et al. [2013]. 250 µL of noodle extract was added with 0.3 mL of 5% $NaNO_2$ and incubated for 5 min in a 10 mL volumetric flask. After 5 min of incubation, 0.3 mL of 10% $AlCl_3$ was added. After 5 min, 2 mL of 1 M NaOH was added and the volume was adjusted to 10 mL with distillated water. Samples were mixed and homogenized before was analyzed using spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ. 510 nm. The result was determined using (+)-catechin standard reference and expressed as mg CE (Catechin Equivalent) per kg of dried noodles.

Total anthocyanin content analysis

Total anthocyanin content was determined on the method of Giustl and Wrolstad [44]. 250 µL samples were added buffer solution at pH 1 and pH 4.5 in 10 mL test tube. And then each of samples was mixed and incubated for 15 min and measured at λ 543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Absorbance (A) of samples was calculated with formula: A =$(A\lambda 543 - A\lambda 700)pH\ 1.0 - (A\lambda 543 - A\lambda 700)pH 4.5$. The total anthocyanin content (mg/mL) was calculated by formula:$\frac{AxMWxDFx1000}{\varepsilon x\ l}$. Where A was absorbance, MW was molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was factor of sample dilution, and ε was absorptivity molar of delphinidin-3-glucoside (29000 L cm^{-1} mol^{-1}).

DPPH free radical scavenging activity

DPPH scavenging activity was measured based on method of Shirazi et al. [45] and Widyawati et al.[46]. Briefly, 10 µL 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. Solution was centrifuged at 5000 rpm for 5 min and absorbance of samples was measured at λ. 517 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant activity of samples was stated as inhibition capacity with gallic acid as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Ferric reducing antioxidant power

FRAP analysis was used the modified method of Al-Temimi and Choundhary [47]. 50 µL of extract in a test tube was added 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^{o}C. After incubation 20 min, solution was added 2.5 ml of 10% mono chloroacetic acid and shaken. Then, 2.5 mL of supernatant was taken and added 2.5 mL of bi-distillated water and 2.5 mL of 0.1% ferric chloride and incubated for 10 min. After incubation, samples were measured absorbance at λ=700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). Antioxidant capacity was used gallic acid as standard reference and expressed as mg GAE (Gallic Acid Equivalent) per kg of dried noodles.

Sensory evaluation

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

Design of experiment and statistical analysis

Design of experiment used a randomized block design (RBD) with two factors, i.e., the four ratios of the composite flour (wheat flour, stink lily flour and κ-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 done in three replications. The homogenous data of triplicate analysis was expressed as the mean ± SD. The one-way analysis of variance (ANOVA) was done and Duncan's New multiple range test (DMRT) was used to determine for 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

Quality of wet noodles including moisture content, water activity, tensile strength, swelling index, cooking loss, and color was shown in Table 2 and Fig.1, 2, 3, and 4. Moisture content and water activity (AW) of raw wet noodles were only significantly influenced the various ratio of composite flour ($p \leq 0.05$) (Fig. 1). However, the interaction of two factors, the difference in the ratio of composite flour and the concentration of butterfly pea extract or the concentration of butterfly pea extract itself, did not have a significant effect on the water content and AW 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 samples had the highest ratio of κ-carrageenan. The increasing of κ-carrageenan proportion influenced the amount of free and bound water in the wet noodle samples that increased the water content of wet noodles. Water content measures the amount of free and weakly bound water in the pores, intermolecular, and intercellular space of samples [15,28,49]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecule [50]. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of gluten network to stability gluten network that increases water binding capacity and retards the migration of water molecules[51,52]. κ-carrageenan can bind water molecule around 25-40 times [53]. The κ-carrageenan can cause the structure change of gluten protein though electrostatic interactions and hydrogen bonding [54,55]. Interaction among protein of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour and κ-carrageenan also changed the conformation of the three-dimensional network structure formation involving electrostatic forces, hydrogen bonds, intra-and inter-molecular disulfide bonds that is be able to establish water mobility in dough of this wet noodles. The effect of this interaction of all components of composite flour significantly influenced of the amount of free water ($p \leq 0.05$) (Fig. 1). The addition of κ-carrageenan between 1-3% in the wet noodle formulation reduced the AW about 0.005-0.006. The capability of κ-carrageenan absorbed water molecules reduces the water mobility in wet noodles due to the involving of hydroxyl, carbonyl, and ester sulphate groups of them to form complex structure [55-57]. The complexity of the reaction among components in wet noodles to form a three-dimensional networking influenced the amount of free water molecules that determined water activity values. The strength of the bonding among the components arranged of wet noodles and water molecules also specified the value of the water activity.

Tensile strength, swelling index, and cooking loss of cooked wet noodles was significant influenced by each factors of the composite flour or the concentration of butterfly pea flower extract ($p \leq 0.05$) (Fig. 1 and 2), but the interaction of the various ratio of composite flour and the concentration of butterfly pea extract was not significant influenced the tensile strength, swelling index, and cooking loss of wet noodles ($p \leq. 0.05$) (Table 2). The increasing of the ratio of κ-carrageenan in composite flour increased the tensile strength and swelling index, and decreased cooking loss of wet noodles, but the increasing of the concentration of butterfly pea extract decreased the tensile strength and increased swelling index and cooking loss of wet noodles. The effect of the ratio of composite flour to the tensile strength ranged between 0.197 to 0.171 g. While the addition of butterfly pea extract caused the tensile strength of wet noodles (T15 and T30) significant lower around 0.003 until 0.008 than control (K1). The highest swelling index values was owned by K3 sample and the lowest swelling index values were belonging of the K0 sample. The swelling index values of wet noodles ranged around 128 to 159 %. The effect of composite flour proportion of wet noodles showed that K0 sample had the highest cooking loss and K3 sample possessed the lowest cooking loss. While the effect of the concentration of butterfly pea extract resulted the lowest cooking loss values of T0 sample and the highest cooking loss values of T30 sample. The cooking loss values of wet noodles ranged around 18 to 19 %.

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

The increasing of swelling index of dough is caused the capability of glucomannan to reduce pore size and increase the pore numbers with uniform size [63]. The synergistic interaction between these hydrocolloids and gluten protein results stronger, more elastic, and stable gel because of the association and lining up of the mannan molecules into the junction zones of helices[64]. The cross-linking and polymerization involving functional groups of gluten protein, κ-carrageenan and glucomannan determined binding force with each other. The stronger attraction between molecules composed cross-linking reduces the particles or molecules loss during cooking[64-66]. Stability of the network dimensional structure of protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in dough of wet noodles that determined tensile strength, swelling index and cooking loss of wet noodles. Schefer et al. [27] and Widyawati et al. [15] explained that phenolic compounds can disturb the interaction between 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 π-π stacking. The phenolic compounds of butterfly pea extract were interacted with κ-carrageenan, glucomannan, protein or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt a three-dimensional networking of interaction among gluten protein, κ-carrageenan and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulphide bridges to form of thiols radicals [65,66]. These compounds can form complexes with protein and hydrocolloids leading to structural and functional changes and influence gel formation though aggregation formation and disulphide bridges breakdown [26,27,67].

Color of wet noodles (Fig. 3 and 4) was significantly influenced by the interaction between the composite flour and butterfly pea extract ($p \leq 0.05$). The L^*, a^*, b^*, C, and ^oh increased with increasing the ratio of composite flour and the concentration of butterfly pea extract. Most of color parameters values were lower than the control (K0T0, K1T0, K2T0, K3T0), except yellowness and chroma values of K2T0 and K3T0, whereas the increasing of amount of butterfly pea extract changed all color parameters. The ranging of L^*, a^*, b^*, C, and ^oh 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 grew with going up the κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. Chroma and hue of wet noodles decreased with increasing of κ-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 κ-carrageenan in composite flour also supported water holding capacity of wet noodles that influenced color. κ-carrageenan was synergized with glucomannan to produce strong stable network that involved sulfhydryl groups. Tako and Konishi [68] reported that κ-carrageenan is capable to associate making polymer structure that involves intra-and intern molecular interaction, such as ionic bonding and electrostatic forces. The mechanism of making three-dimensional network structure that implicated all component of composite flour was very complicated because they involved polar and non-polar functional groups and many kinds of interaction of them. These were influenced water content and water activity of wet noodles that were impacted wet noodle color. The other cause of wet noodles was anthocyanin pigment from butterfly pea extract. Gamage et al. [69] reported that anthocyanin pigment of butterfly pea is delfinidin-3-glucoside having blue color. Increasing of extract concentration declined lightness, redness, yellowness and chroma as well as changed hue color from yellow to be green until 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. [70] and Padmawati et al. [71] also founded similarity of their research. Anthocyanin pigment of butterfly pea extract can be interacted with color of stinky lily and κ-carrageenan impacted color change of wet noodles. Thus, the sample T0 is yellow color, T15 is green color and T30 is blue color. Color intensity showed as chroma values of yellow values increased along with higher proportion of κ-carrageenan at the same concentration of butterfly pea extract, but the higher concentration of butterfly pea extract declined green and blue colors of wet noodles at the same proportion of composite flour. Wet noodle color also estimated to be influenced by the phenolic compound content which underwent polymerization or degradation during the heating proses. Widyawati et al. [28] reported that bioactive compounds in pluchea extract can change wet noodle color because of discoloration of pigment during cooking. K2T30 was wet noodles having strongest blue color due to different interaction of anthocyanin and hydrocolloid compounds, especially κ-carrageenan that were capable to reduce intensity of blue color or chroma values.

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

TPC, TFC and TAC were shown in Fig. 5. The TPC and TFC of wet noodles were significantly influenced by interaction between two parameters of the ratio of composite flour and the concentration of butterfly pea extracts ($p \leq 0.05$). The highest proportion of κ-carrageenan and butterfly pea extract resulted the highest TPC and TFC. The K2T30 had the highest TPC and TFC as ~ 207 mg GAE/kg dried noodles and ~57 mg CE/kg dried noodles, respectively. While the TAC of wet noodles was only influenced by the concentration of butterfly pea extract, the increase in extract addition leading to an increase in TAC. The extract substitution at T30 was obtained about 3.92±0.18 mg delfidine-3-glucoside/kg dried noodles of TAC. Based on Pearson correlation, TPC of wet noodles was strong and positive correlated with TFC at T0 treatment (r= 0.955), T15 treatment (r=0.946), T30 (r=0.765), while TPC of samples was weak and positive correlated with TAC at T0 treatment (r=0.153) and T30 (r=0.067), except the samples at T15 treatment had correlation coefficient -0.092 (Table 7). The bioactive compounds of wet noodles were correlated with quality properties and antioxidant activity (AOA). Dominant anthocyanin pigment from butterfly pea extract is delphinidin [72] around 2.41 mg/g samples [73] that has free more acyl groups and aglycone structure [74] and can be used as natural pigment. The addition of butterfly pea extract influenced the color of wet noodles. Anthocyanin is potential as antioxidant agent through free-radical scavenging pathway, cyclooxygenase pathway, nitrogen-activated protein kinase pathway, and inflammatory cytokines signaling [75,76]. Nevertheless, butterfly pea extract also composes tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6"-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose) [20,21], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids [74], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexen, 1-methyl-4(1-methylethylideme), hirsutene [77,78], that contribute to have antioxidant activity [18,78]. *Clitoria ternatea* shows potential as antioxidant activity based on an 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^{2+} reducing power assays [78]. TPC and TFC of wet noodles increased along with the higher proportion of glucomannan in composite flour and the higher concentration of butterfly pea extract. Zhou et al. [79] claimed that glucomannan in stinky lily has hydroxyl groups that can be reacted with Folin Ciocalteus's phenol reagent. Devaraj et al. [80] reported that 3,5-acetyltalbulin is flavonoid compounds in glucomannan can be bound complexes with $AlCl_3$.

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 Fig. 5. The proportion of composite flour and concentration of butterfly pea extracts significantly affected the DPPH ($p \leq 0.05$). The noodles had DPPH ranging from 3 to 48 mg GAE/kg dried noodles. The noodles including composite flour of K0 and K1 and without of butterfly pea extracts (K0T0 and K1T0) had lowest DPPH, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest DPPH. Pearson correlation showed that TPC and TFC were strong and positive correlated with DPPH (Table 7). Correlated coefficient values (r) between TPC and AOA at T0, T15 and T30 treatments were 0.893, 0.815, and 0.883, respectively. Whereas r values between TFC and DPPH at T0 treatment were 0.883, at T15 treatment were 0.739, and at T30 treatment were 0.753. However, correlation coefficient values between TAC and AOA at T0, T15 and T30 treatments were 0.123, 0.127, and 0.194, respectively. Interaction among glucomannan, phenolic compounds, amylose, gliadin and glutelin in dough of wet noodles determined number and position of free hydroxyl groups of them that influenced TPC, TFC, and DPPH. Widyawati et al. [46] said that free radical inhibition activity and chelating agent of phenolic compounds depends on position of hydroxyl groups and conjugated double bond of phenolic structures. The values of TPC, TFC and DPPH increased with higher level of stinky lily flour and κ-carrageenan proportion and butterfly pea extract significantly up to 18 and 2% (w/w) glucomannan and κ-carrageenan and 15% (w/w) extract, but the using of 17 and 3% (w/w) glucomannan and κ-carrageenan and 30% (w/w) extract showed a significant decrease. This showed that the use of stinky lily flour and k-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 concentration of butterfly pea extracts ($p \leq 5\%$). FRAP was used to measure the capability of antioxidant compounds to reduce Fe^{3+} ion to be Fe^{2+} ion. FRAP capability of wet noodles was lower than DPPH ranging 0.01 to 0.03 mg GAE/kg dried noodles. The noodles without κ-carrageenan and butterfly pea extracts (K0T0) had lowest FRAP, while the samples containing composite flour K2 with butterfly pea extracts 30% (K2T30) had highest FRAP. Pearson correlation values showed that TPC dan TFC at T0 and T30 treatments had strong and positive correlated to FRAP activity, but T15 treatment possessed weak and positive correlation (Table 7). Correlation coefficient (r) values of TAC at T0 treatment was weak and positive correlated to FRAP samples, but r values at T15 and T30 treatments owned weak and negative correlation (Table 3). The correlation between DPPH and FRAP activities was obtained that DPPH method was highly correlated with FRAP method at T0 and T30 treatments and lowly correlated at T15 treatment (Table 3). Based on DPPH and FRAP methods showed that capability of wet noodles to scavenge free radical was higher than them to reduce ferric ion. It proved that bioactive compounds of wet noodles were more potential as free radical scavengers or hydrogen donors than as donor electron. Compounds that have capability to reducing power can act as primary and secondary antioxidant [81,82]. Poli et al. [83] said that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al. [84] claimed that a secondary antioxidant is natural antioxidant that has capability to reduce ferric ion (FRAP). Based on AOA assay, the results showed that phenolic compounds indicated strong and positive correlation with flavonoid compounds because of they are major phenolic compounds that are potential as antioxidant activities pass through highly effective scavenger of various free radicals. The effectivity of flavonoid compounds to inhibit free radicals and chelating agents is influenced by number and position of hydrogen groups and conjugated diene at A, B, and C rings [85-87]. Previous studies have proven that TPC and TFC exhibit significant contributor to scavenge free radicals [88-90]. However, TAC showed a weak correlation with TFC, TPC or AOA, although Choi et al. [89] stated that TPC and anthocyanins have a significant and positive correlation with AOA but anthocyanins were insignificantly correlated with AOA. Different structure of anthocyanins in samples determines AOA. Polymer anthocyanins or anthocyanin complexed with other molecules assign capability of them to electron or hydrogen donors. Martin et al. [91] informed that the anthocyanins are major groups of phenolic pigments that are an essential antioxidant activity depend on a steric hindrance of their chemical structure, such as number and position of hydroxyl groups and the conjugated doubles bonds, as well as the presence of electron in the structural ring. However, TPC and TFC at T0 and T30 treatments were highly and positive correlated with FRAP assay due to the role of phenolic compounds involved reducing power that contributed them to donor electron. Paddayappa et al. [82] reported that the phenolic compounds are capable to embroiled redox activities with action as hydrogen donor and reducing agents. The weakly relationship between TPC or 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 hedonic method, showed that composite flour and butterfly pea extract additions significantly influenced color, aroma, taste, and texture preferences ($p \leq 0.05$) (Table 4). 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. The using of butterfly pea extracts decreased preference values of color, aroma, taste, and texture attributes of wet noodles. Anthocyanin of butterfly pea extract gave different intensity of wet noodle's color that resulted color degradation from yellow, green until blue color impacted color preference of wet noodles. Nugroho et al. [48] also informed that addition of butterfly pea extract upgraded preference of panelist to dried noodles. Aroma of wet noodles was also affected by two parameters of treatments, the results showed that the higher proportion of stinky lily caused the stronger musty smell of wet noodles. Utami et al. [92] claimed that oxalic acid of stinky lily flour contributes to odor of rice paper. Therefore, a high proportion of k-carrageenan can reduce the proportion of stink lily flour, thereby increasing the panelist's preference for aroma. Sumartini and Putri [93] informed that panelist is more like noodles substituted the higher κ-carrageenan. Kurniadi et al. [94] and Widyawati et al. [15] said that κ-carrageenan is odorless material which doesn't result aroma of wet noodles. Neda et al. [77] added that volatile compounds of butterfly pea extract can mask musty smell of stinky lily flour, such as pentanal and mome inositol, Padmawati et al. [71] informed that they can gave sweety and sharp aroma. Taste preference of panelist to wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin [95] due to Maillard reaction of stinky lily flour processing. Nevertheless, using of butterfly pea extract at higher concentration of wet noodles increased bitter taste related to tannin compounds in this flower, this is supported by Hasby et al. [96] and Handayani and Kumalasari [97]. Effect of composite flour proportion and butterfly pea extract also appeared to texture preference of wet noodles. Panelist was likely wet noodles that was not break up easily that K3T0 samples were chewy and elastic wet noodles, this was supported by tensile strength of wet noodles because of the different concentration of butterfly pea extract. The addition butterfly pea extract at higher concentration resulted sticky, break easy and less chewy wet noodles [26,27,85,97] due to competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel [98]. Based on index effectiveness test, the noodles including composite flour of K3 and butterfly pea extract of 30% (K3T30) were the best treatment with total score of 1.0504.

Conclusions

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

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Conflict of Interest

The authors declare no conflict of interest

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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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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.

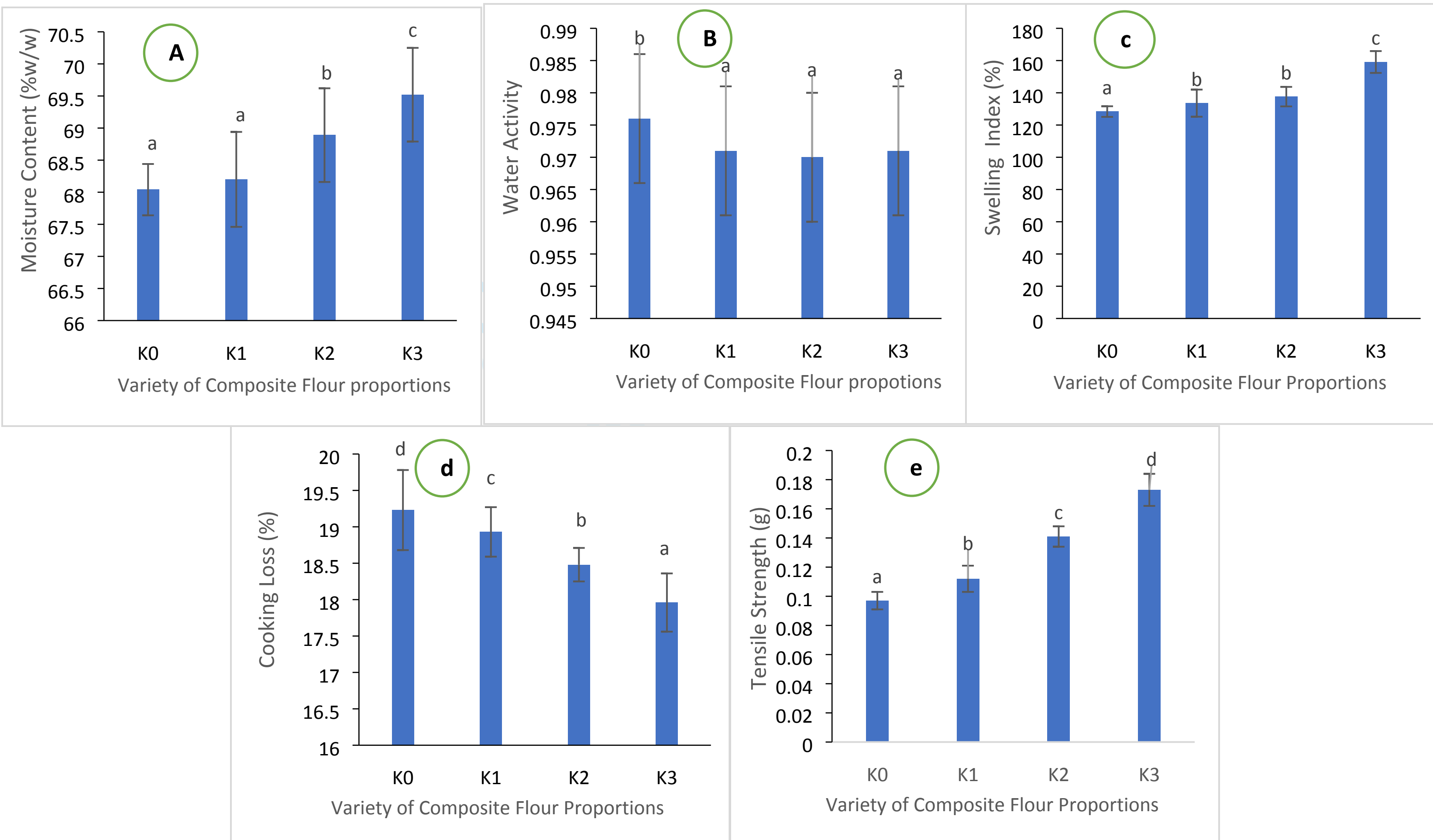

Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets)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

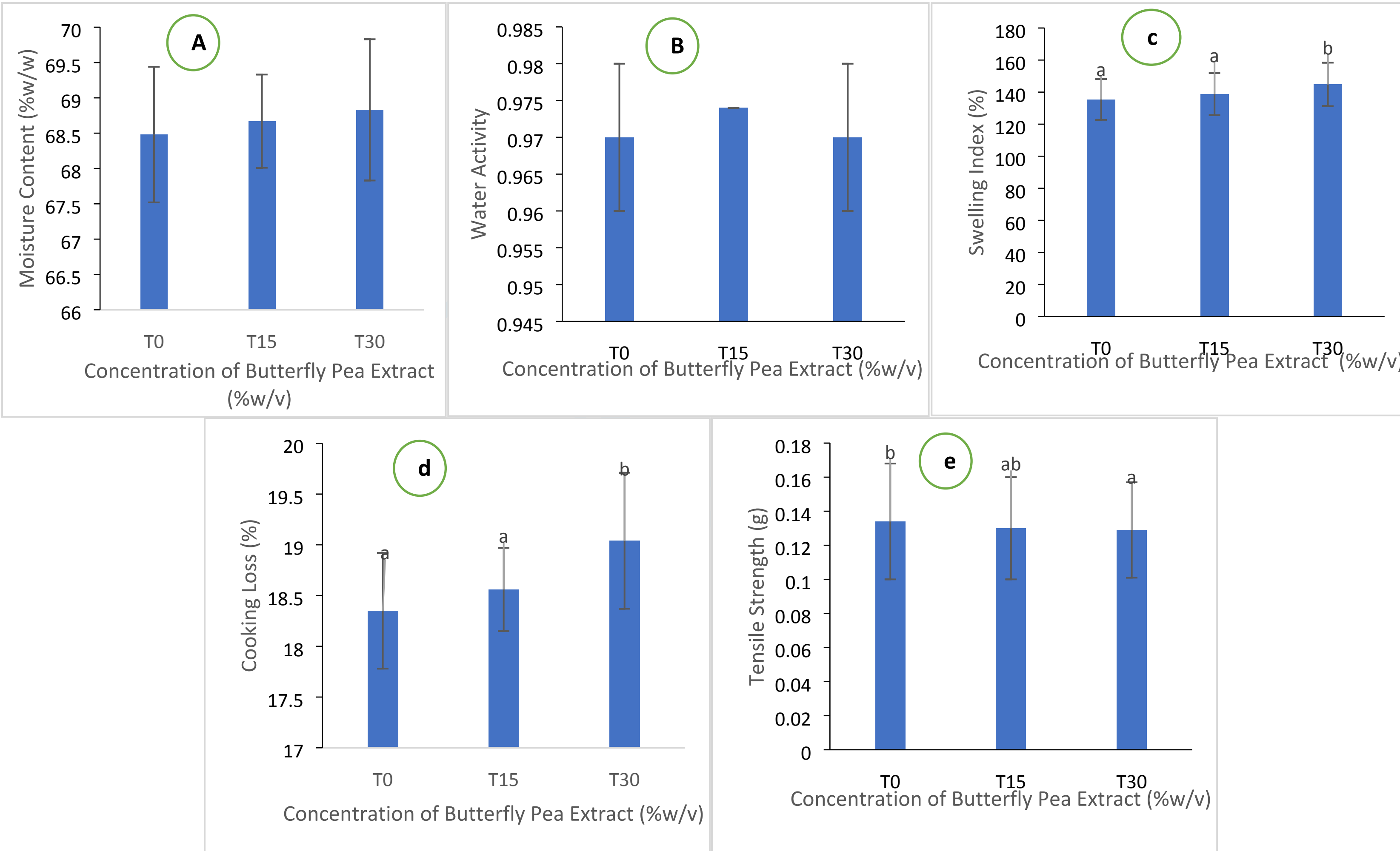

Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

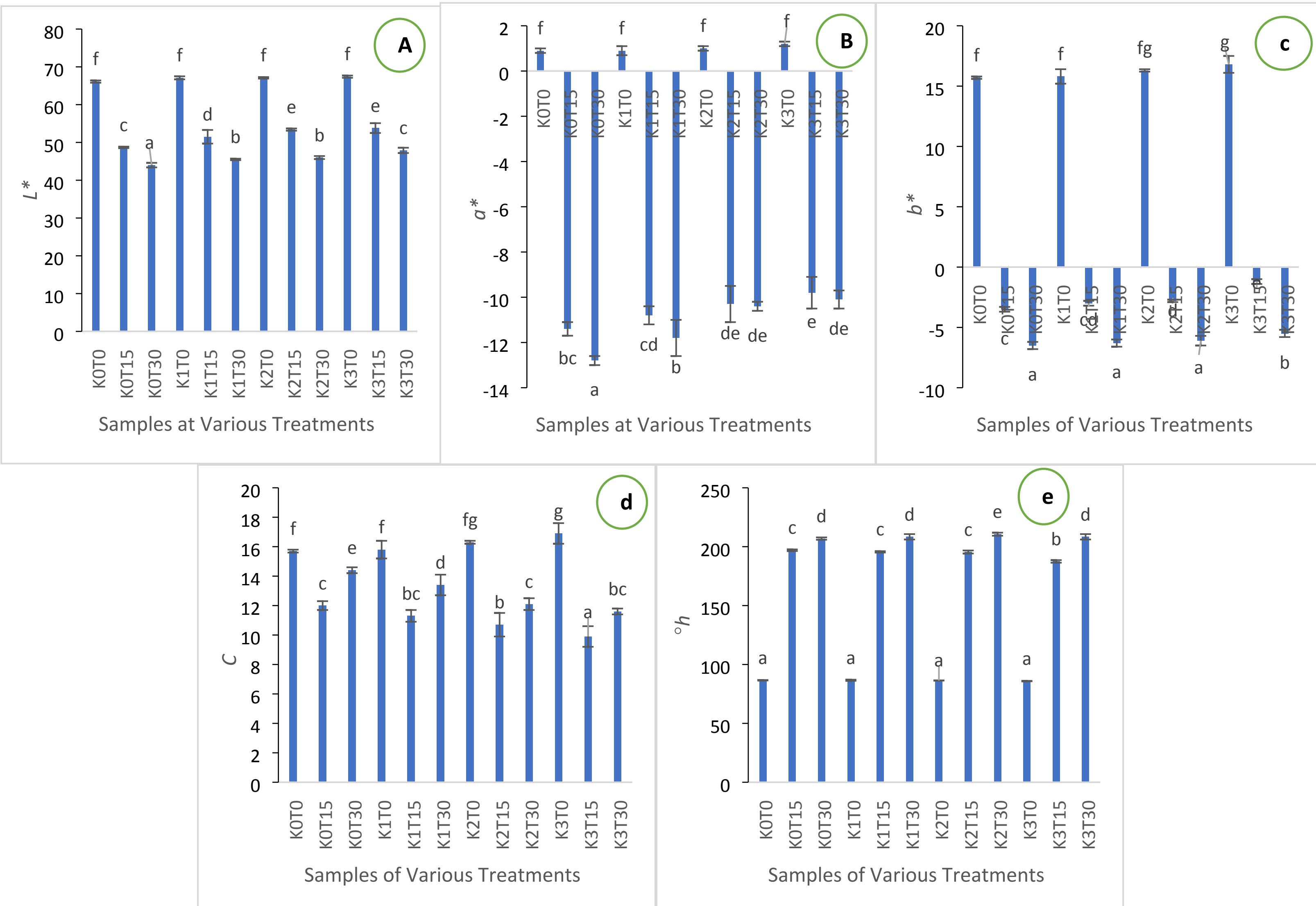

Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

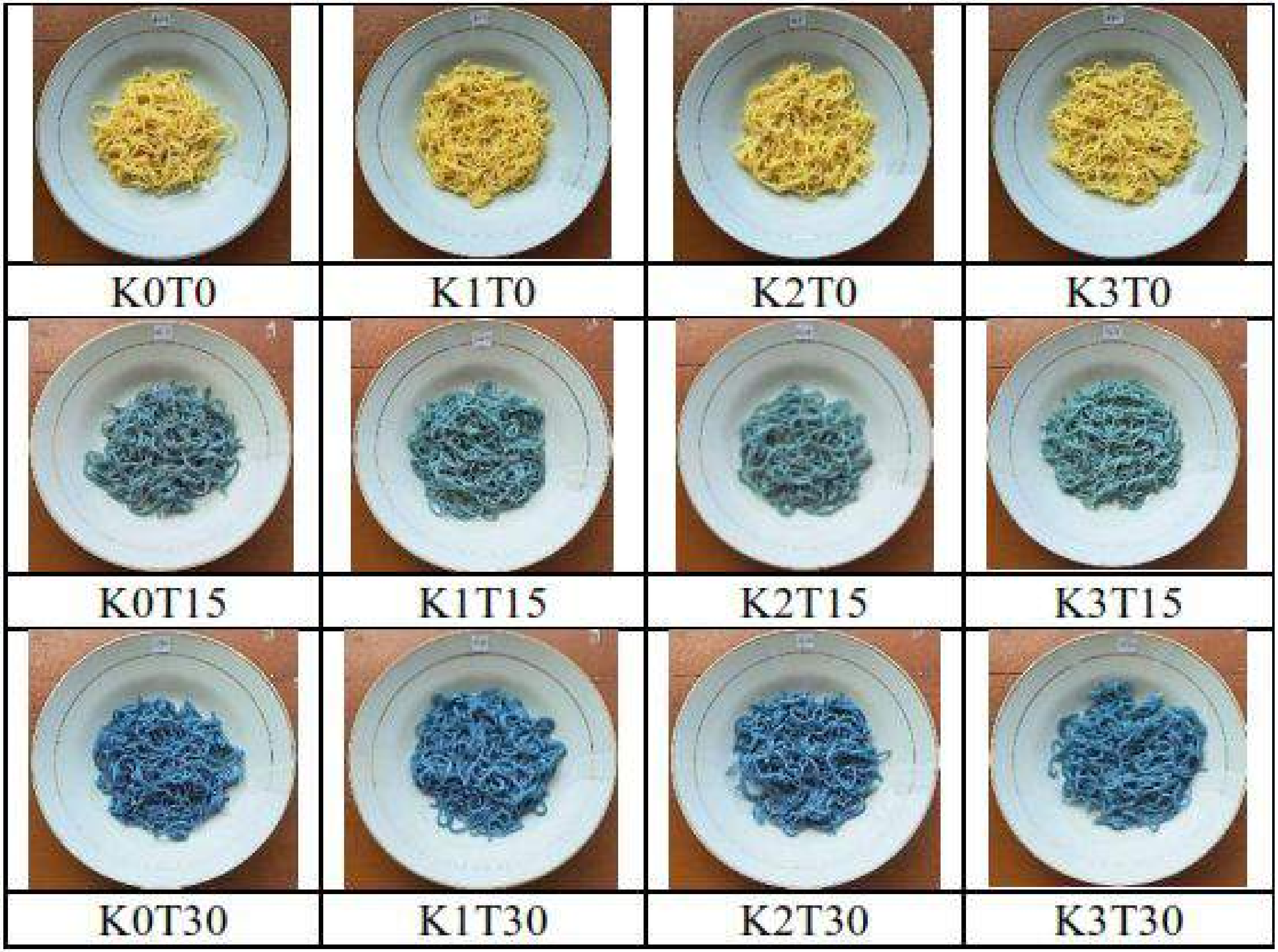

Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

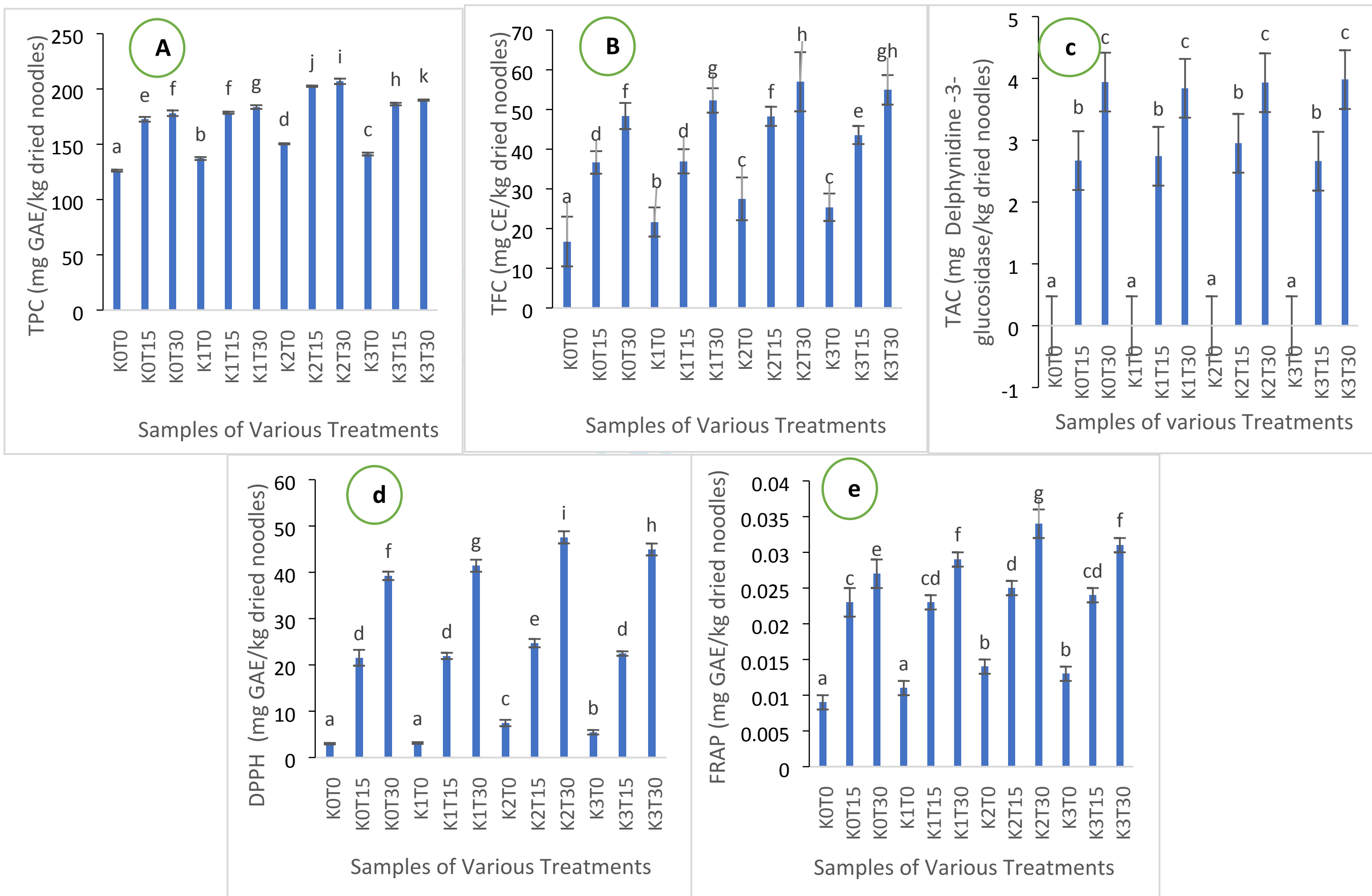

Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (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^{a}	7.41±3.80^{a}	8.71±3.16^{a}	10.78±2.86^{abcde}	0.1597
K0T15	8.96±3.38^{b}	7.75±3.89^{b}	9.35±3.36^{cde}	11.19±3.10^{abcd}	0.6219
K0T30	8.93±3.50^{bc}	7.71±3.76^{c}	9.26±3.17^{bcd}	11.13±3.09^{a}	0.6691
K1T0	8.74±3.62^{a}	8.13±3.56^{ab}	9.58±3.13^{ab}	11.33±3.12^{de}	0.4339
K1T15	9.98±3.06^{bc}	8.40±3.28^{c}	10.16±2.59^{def}	10.61±2.82^{ab}	0.7086
K1T30	10.08±3.28^{bc}	9.10±3.08^{c}	10.44±2.32^{bcd}	10.36±2.81^{ab}	0.7389
K2T0	10.41±3.01^{a}	9.39±3.27^{ab}	11.04±2.44^{ab}	10.55±2.60^{cde}	0.3969
K2T15	10.8±2.85^{bc}	9.26±3.10^{c}	10.11±2.76^{f}	10.89±2.65^{abcd}	0.9219
K2T30	10.73±3.02^{c}	9.10±3.46^{c}	9.85±2.99^{def}	10.16±2.74^{abc}	0.9112
K3T0	10.73±3.42^{a}	9.19±3.38^{b}	9.93±2.50^{bc}	10.34±2.84^{e}	0.5249
K3T15	10.91±3.23^{bc}	9.48±3.56^{c}	10.45±2.82^{cde}	10.49±2.68^{bcde}	0.9235
K3T30	10.88±3.14^{c}	9.49±3.59^{c}	10.81±2.74^{ef}	10.86±2.60^{bcde}	**1.0504**

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, $p \leq 5\%$.

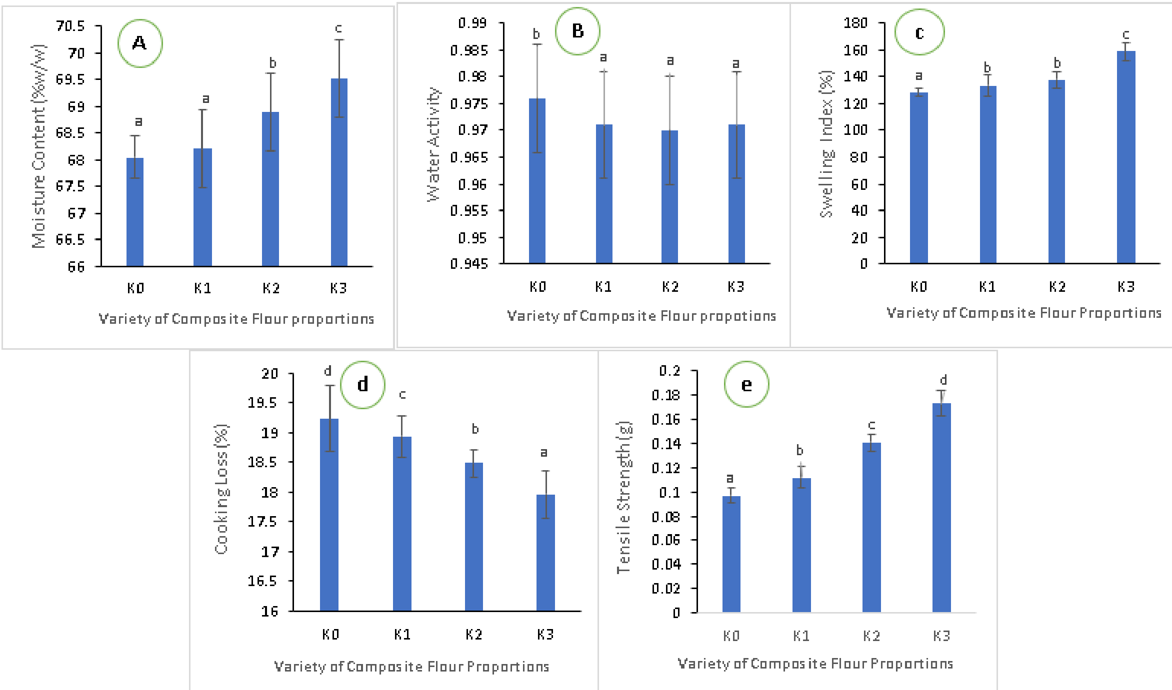

Figure 1. Effect of composite flour proportions to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets)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

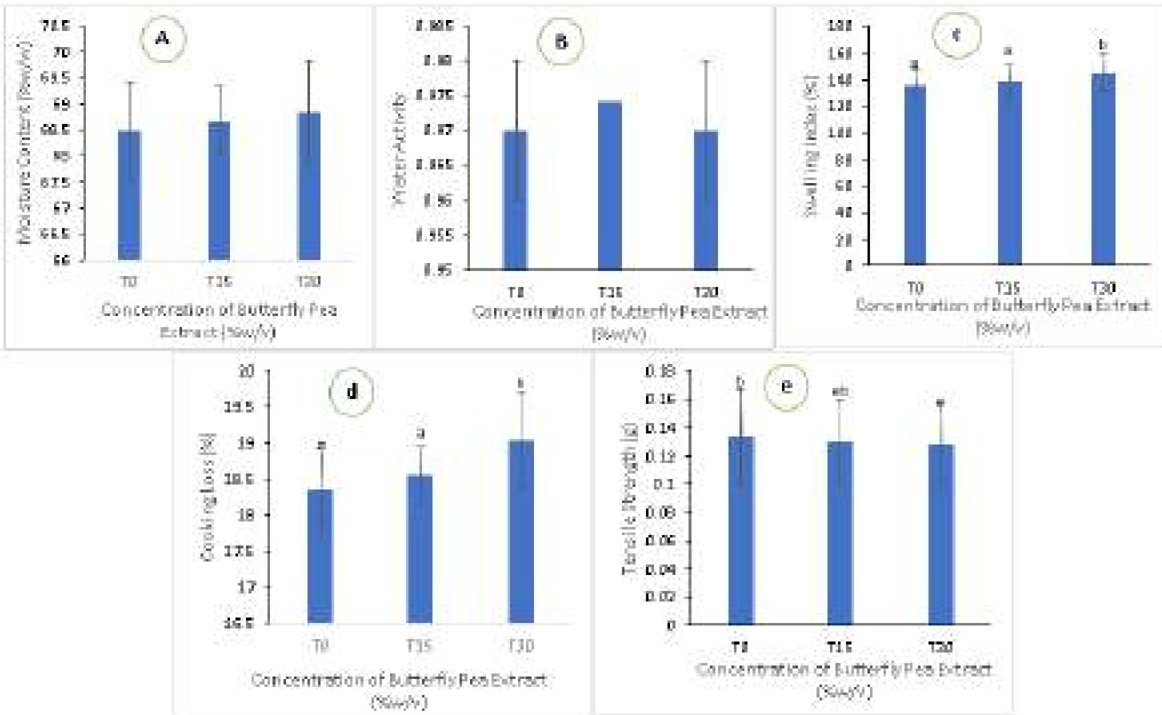

Figure 2. Effect of butterfly pea extract concentration to quality properties of wet noodles (a. Moisture content, b. Water activity, c. Swelling index, d. Cooking loss, e. Tensile strength). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

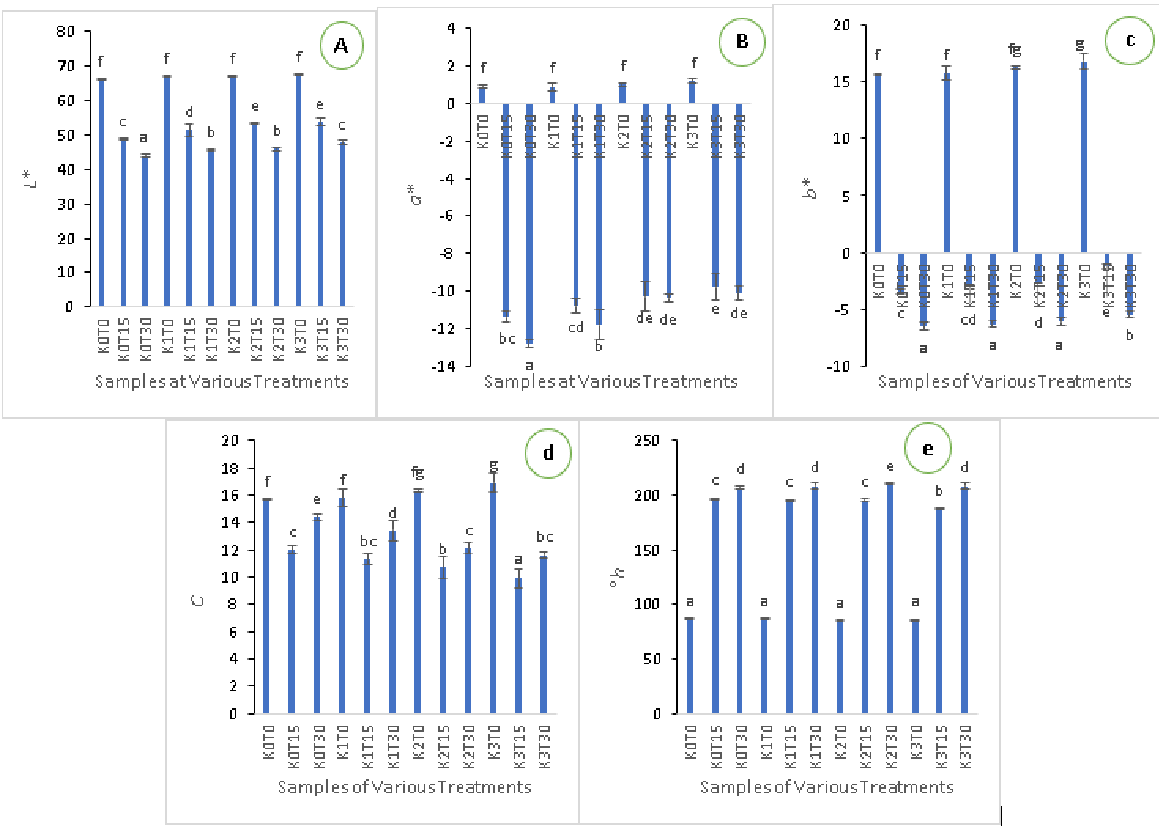

Figure 3. Effect of interaction between composite flour and butterfly pea extract to wet noodle's color (a. *Lightness/L**, b. *Redness/a**, c. *Yellowness/b**, d. *Chroma/C*, e. *Hue/°h*). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts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

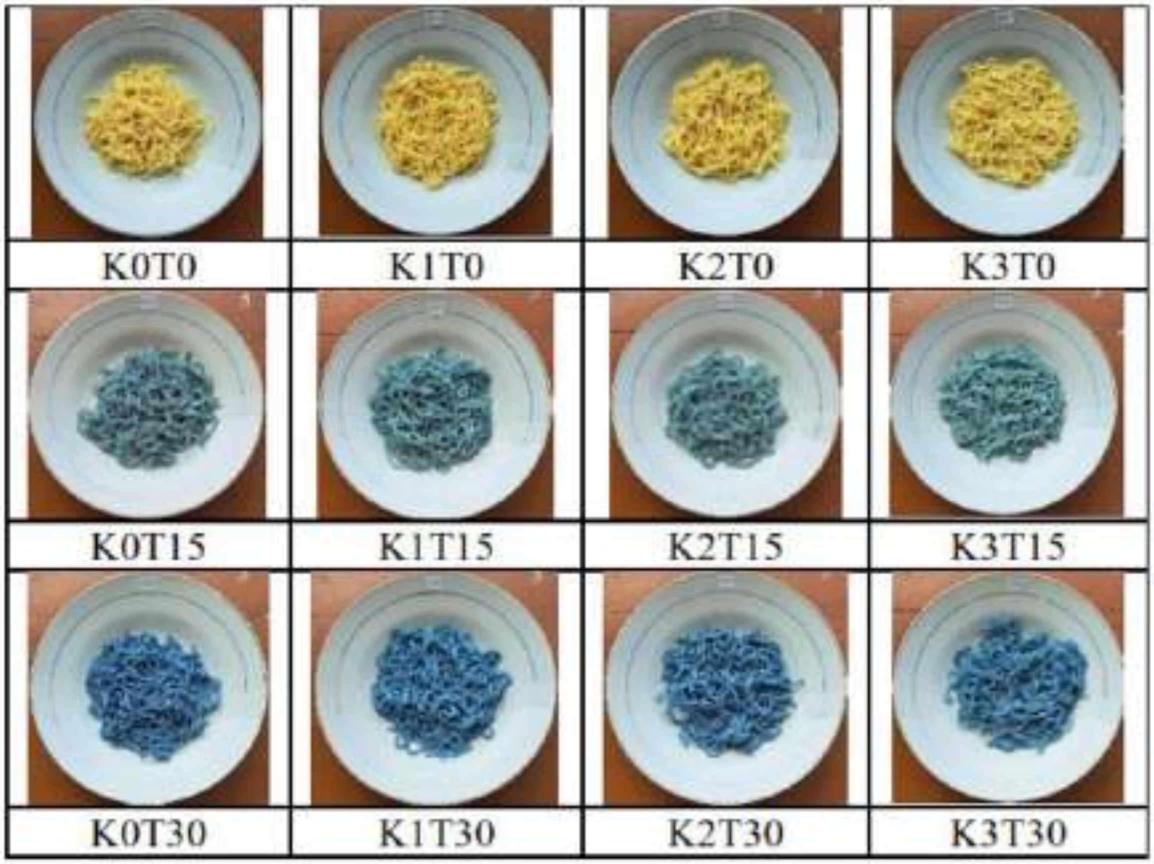

Figure 4. Color of wet noodles at various proportion of composite flour and concentration of butterfly pea flower extract

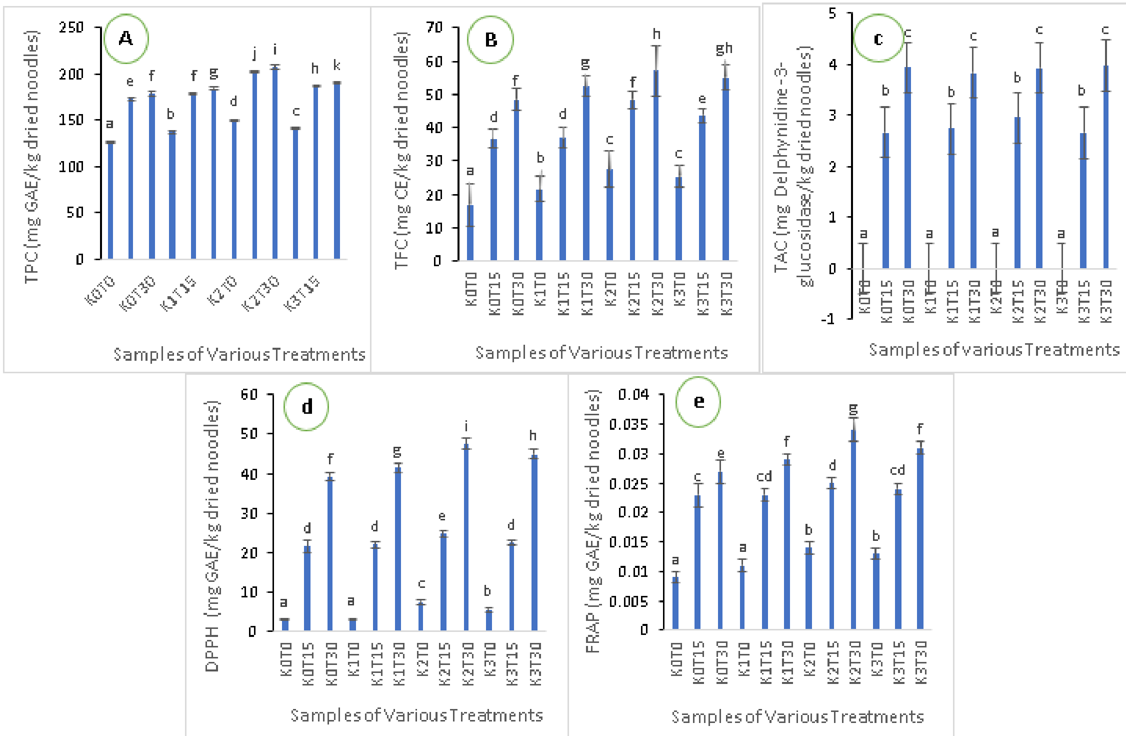

Figure 5. Effect of interaction between composite flour and butterfly pea extract to wet noodle's bioactive compounds and antioxidant activity (a. TPC, b. TFC, c. TAC, d. DPPH, e. FRAP). The results were presented as SD of the means that were achieved by triplicate. Means with different superscripts (alphabets) in the histogram are significantly different, p ≤ 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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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)

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K0T30	8.93±3.50[bc]	7.71±3.76[c]	9.26±3.17[bcd]	11.13±3.09[a]	0.6691
K1T0	8.74±3.62[a]	8.13±3.56[ab]	9.58±3.13[ab]	11.33±3.12[de]	0.4339
K1T15	9.98±3.06[bc]	8.40±3.28[c]	10.16±2.59[def]	10.61±2.82[ab]	0.7086
K1T30	10.08±3.28[bc]	9.10±3.08[c]	10.44±2.32[bcd]	10.36±2.81[ab]	0.7389
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K2T15	10.8±2.85[bc]	9.26±3.10[c]	10.11±2.76[f]	10.89±2.65[abcd]	0.9219
K2T30	10.73±3.02[c]	9.10±3.46[c]	9.85±2.99[def]	10.16±2.74[abc]	0.9112
K3T0	10.73±3.42[a]	9.19±3.38[b]	9.93±2.50[bc]	10.34±2.84[e]	0.5249
K3T15	10.91±3.23[bc]	9.48±3.56[c]	10.45±2.82[cde]	10.49±2.68[bcde]	0.9235
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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

Gmail

Paini Sri Widyawati <paini@ukwms.ac.id>

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

Admin BPR <onbehalfof@manuscriptcentral.com> 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.

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=8d51b5676c2e4be3a65e472b4ab4a6ea

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.

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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 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 k-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.
https://www.maxapress.com/bpr/for_authors

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

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Abstract

The improvement of wet noodles' qualities, sensory, and functional properties was made by using the composite flour base added with the butterfly pea flower extract. The composite flour consisted of wheat flour and stink lily flour, and κ-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 the 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 κ-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-κ-carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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

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. [1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al. [2] 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 [3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al. [4] 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. [5,6]. ~~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.~~

~~Composite flour is a mixture of several types of flour, usually composed of several types of carbohydrate sources (tubers, legumes, cereals) with or without wheat flour [1,2]. The composite flour is made to obtain suitable material characteristics for the desired processed product with certain functional properties [3]. The use of composite flour in wet noodles has been widely carried out to increase its functional values and several characteristics, including physical, chemical, and sensory properties. Siddeeg et al.[4] used wheat-sorghum-guar flour and wheat-millet-guar flour to improve the acceptability of wet noodles. Efendi et al.[5] stated that potato starch and tapioca flour at a ratio of 50:50 (% w/w) can enhance the functional values of wet noodles. Dhull & Sandhu[6]~~

claimed that noodles made from wheat flour blended with fenugreek flour for up to 7 % produced a good texture and a high consumer acceptance. Park et al.[7] utilized the blended ratio of purple-colored wheat bran to increase wet noodles' quality and antioxidant activity.

A previous study used stinky lily flour or konjac flour (*Amorphophallus muelleri*) composited with wheat flour to increase the functional values of noodles by increasing the biological activities (anti-obesity, antihyperglycemic, anti-hyper cholesterol, and antioxidant) and prolonging gastric emptying time[8,9]. However, adding stink lily flour to base noodle flour resulted in wet noodles' limited elasticity and tensile strength[10,11]. Therefore, the κ-carrageenan was introduced to improve the texture properties of wet noodles. Those components collaborated with glucomannan to form cross-linking with glutenin and gliadin by inter- and intra-molecular bonds, improving noodle texture [12-14]. Widyawati et al. [15] explained that using the composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[16] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[15] 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 [17]. This flower has phytochemical compounds that benefit as antioxidant sources [18,19], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides [20,21]. Anthocyanins of the butterfly pea flower has been used as natural colorants in many food products [22,23], one of them is wet noodle[24,25]. 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 [26]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility [27]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[15,28], gendarussa leaf (*Justicia gendarussa* Burm.F.)[29], carrot and beetroot[30], kelakai leaf[31] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[25] 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 κ-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. Widyawati et al. [7] explained that using the composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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. [8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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.

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Materials and Methods

Raw materials and preparation

Butterfly pea flowers were obtained from Penjaringan Sari ~~garden~~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 ^{o}C for 3 min based on the modified method of Widyawati et al. [20] and Purwanto et al. [24] to get 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 κ-carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

Chemical 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 noodles preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al. [25~~11~~], 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 get noodles about 0.1 cm wide. ~~. The dough was sheeted and cut using rollers equipped with cutting blades (Oxone OX355AT, China).~~ Raw wet noodle strains were sprinkled with tapioca flour (Rose Brand, PT Budi Starch & Sweetener, Tbk) (4% w/w) before heated in 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.[7~~15~~]. 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 5000 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 t~~T~~hen ~~supernatant was~~ 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 [26~~32~~]. 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 [27~~33~~].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28~~39~~]. 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 mm/s, 3 mm, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 sec, 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.[29~~35~~]. The parameters measured were lightness (*L**), redness (*a**), yellowness (*b**), Hue (°*h*), and chroma (C). *L** value ranged from 0-100 expresses brightness, and *a** value shows red color with an interval between -80 - +100. *b** value represents a yellow color with an interval of -70 - +70 [30~~6~~]. *C* indicates the color intensity and °*h* states the color of samples [31~~7~~].

Swelling index analysis

The swelling index was determined using a modified method by Islamiya et al.[32~~8~~]. 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~~noodles [33~~9~~]. 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 by Aditia ~~et al.~~ et al. [34~~40~~]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that ~~turn~~ turns ~~to~~ cloudy and thick [35~~41~~]. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 ^{o}C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 ^{o}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 Eyele ~~et al.~~ et al. [36~~42~~]. About 50 µL 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 % Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ 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 = [(As-0.0287)/0.0004][2 mL/x g][1L/1000mL][1000g/1kg], 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 by Li ~~et al.~~ et al. [37~~2013~~]. The procedure began with mixing 0.3 mL of 5 % $NaNO_2$ and 250 µL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10 % $AlCl_3$ was added into 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 prior tobefore analysis using a spectrophotometer (Spectrophotometer UV-Vis 1800, Shimadzu, Japan) at λ. 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 = [(As-0.0014)/0.0008][2 mL/x g][1L/1000mL][1000g/1kg], 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 Giustl Giusti and Wrolstad [3844]. About 250 µL 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 λ 543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: $A = (A\lambda 543 - A\lambda 700)pH\ 1.0 - (A\lambda 543 - A\lambda 700)pH 4.5$. The total anthocyanin monomer content (TA) (mg/mL) was calculated with the formula: $\frac{AxMWxDFx1000}{\varepsilon\ x\ l}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29000 L cm^{-1} mol^{-1}). TA monomer (mg delphinidine-3-glucoside/kg dried noodles) was calculated using the equation= [TA (mg/L)][2mL/x g][1L/1000mL][1000g/1kg], where x=the weight of dried noodles.

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

DPPH analysis was measured based on the methods of Shirazi et al.[et al. [3945] and Widyawati et al.[et al. [406]. Briefly, 10 µL 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 5000 rpm for 5 min, and the absorbance of samples was measured at λ 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) (%) = [(A0-As)/A0]x 100%, where A0= absorbance of the control and As=absorbance of the samples. DPPH free radical scavenging activity (mg GAE/kg dried noodles) = [(y-2.4741)/0.1405] [2mL/x g][1L/1000mL][1000g/1kg], where x=the weight of dried noodles.

Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi and Choundhary [417]. Approximately 50 µL 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 ^{o}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 λ 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:

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

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

Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on Nugroho et al.[428] 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 dislike, and 15 was very 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 twelve (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 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 like it. The best treatment was determined by the index effectiveness test [43]. 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 determining of 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)

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 x 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 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 κ-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 three replications. The homogenous triplicate data were expressed as the mean ± SD. The one-way analysis of variance (ANOVA) was done, and Duncan's New multiple range test (DMRT) was used to determine the differences between means (p≤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 Table 2, 3, 4, dan 5, and Fig.1., 2, 3, and 4. Moisture content and water activity (A_w) of raw wet noodles were only significantly influenced by the various ratios of composite flour (p≤0.05) (Table 3Fig. 1). 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≤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 κ-carrageenan. An increase of κ-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 [715,208]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules [449]. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of gluten network to stabilize the gluten network, increasing water binding capacity and retarding the migration of water molecules [4550]. □-carrageenan can bind water molecules around 25-40 times [4651]. The κ-carrageenan can cause a structure change of in gluten protein through electrostatic interactions and hydrogen bonding [4752]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and □-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 composite flour significantly influenced the amount of free water ($p \leq 0.05$) (Table 3Fig. 1). The addition of κ-carrageenan between 1-3 % in the wet noodle formulation reduced the A_w by about 0.005-0.006. The capability of □-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 them to form complex structures [4853]. 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 ($p \leq 0.05$) (Table 3 Fig. 1 and 42). 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 κ-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 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 glutelin, gliadin, glucomannan, κ-carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistance to break and gel formation. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[linkages [4954] that can bind water molecule to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times [5055] to form a strong gel that increases the viscosity and swelling index of the dough [516]. Park and Baik [527] stated that the gluten network formation affects the tensile strength of noodles. Huang et al. [4853] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[4550] 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[538]. 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 [549]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[549,5560]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[1927] and Widyawati et al.[715] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[5560]. 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 [1926,207,5661].

The color of wet noodles (Table 5 Fig. 3 and Fig. 14) was significantly influenced by the interaction between the composite flour and butterfly pea extract ($p \leq 0.05$). The L^*, a^*, b^*, C, and ^oh 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 °*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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Masakuni and Konishi[5762] reported that κ-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. Gamage et al.[5863] 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.[5964] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[208] 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 κ-carrageenan, that could reduce the intensity of blue color or chroma values.

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

The results of TPC, TFC, and TAC are shown in Table 6Fig. 5. 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 ($p \le 0.05$). The highest proportion of κ-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±0.18 mg delfidine-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). 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 [6065], around 2.41 mg/g samples [616] that has free more acyl groups and aglycone structure [627] 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 [638]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6”-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose) [1220,1321], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids [627], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[649], that contribute to the antioxidant activity [108,649]. *Clitoria ternatea* shows to exhibit 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^{2+} reducing power assays [649]. 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. [6570] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al. [6671] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 6Fig. 5. The proportion of composite flour and the concentration of butterfly pea extracts significantly affected the DPPH results ($p \le 0.05$). 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.[40~~6~~] 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 κ-carrageenan proportion and butterfly pea extract for up to 18 and 2 % (w/w) of stinky lily flour and κ-carrageenan and 15 % (w/w) of extract. However, the use of 17 and 3 % (w/w) of stinky lily flour and κ-carrageenan and 30 % (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to ~~be~~ 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 κ-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 ~~T~~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~~3~~). 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

733). 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[6772]. Poli et al.[6873] stated that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[6974] claimed that a secondary antioxidant is a natural antioxidant that has capability tocan 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[7075]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[716]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[716] 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.[727] 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 doubles 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 donating electrons. Paddayappa et al.[6772] 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 additions significantly influenced color, aroma, taste, and texture preferences ($p \leq 0.05$) (Table 84). 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.[428] also informed 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. [738] claimed that oxalic acid contained in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini and Putri[749] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[715] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al. [638] 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.[7580] revealed that butterfly pea extract could give a sweet and sharp aroma. The panelists' taste preference to for wet noodles without butterfly pea extract addition was caused by alkaloid compounds, i.e., conisin[7681], 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 and Kumalasari [7782]. The effect of composite flour proportion and butterfly pea extract addition also appeared to 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 [1826,1927,7782] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel [7883]. 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 κ-carrageenan and butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan, κ-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 extracts improved color, bioactive content, and antioxidant activity and enhanced panelist preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of resulting wet noodles.

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Conflict of Interest

The authors declare no conflict of interest

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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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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

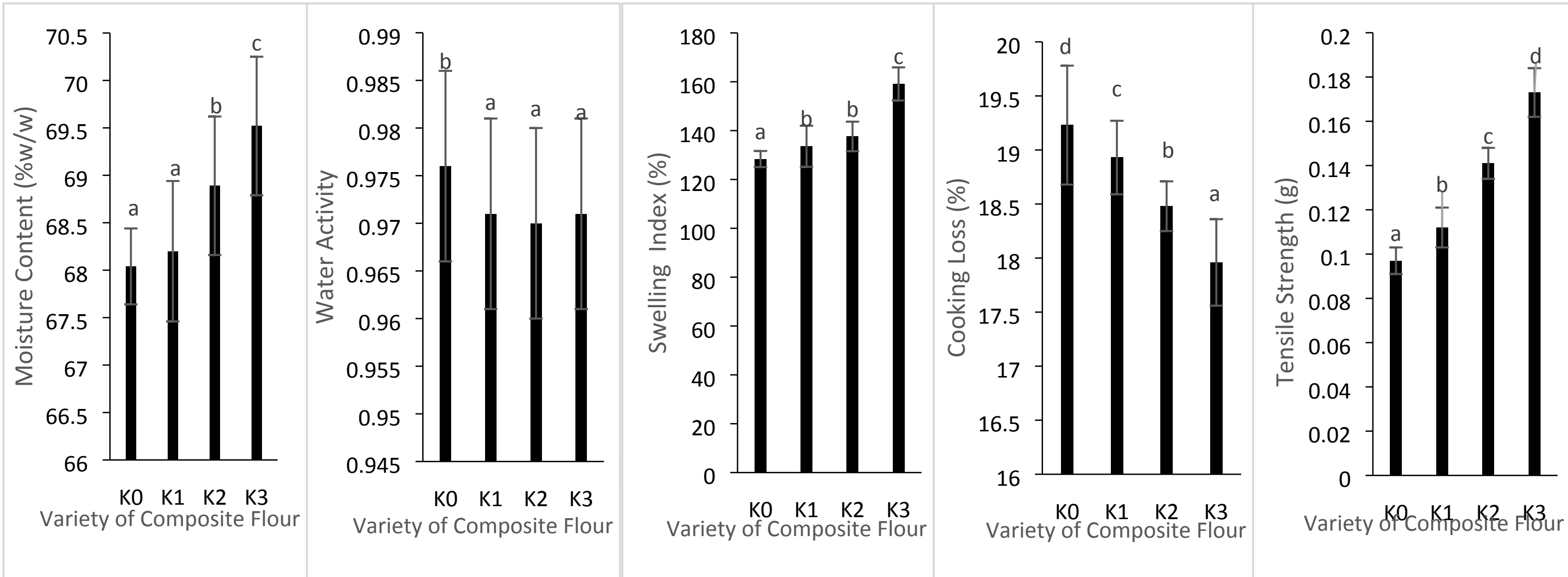
Samples	Moisture Content (% w/w)	Water Activity	Swelling Index (%)	Cooking Loss (%)	Tensile Strength (g)
K0T0	67.94±0.11	0.975±0.008	126.39±2.06	18.91±0.03	0.102±0.008
K0T15	68.31±0.07	0.976±0.005	126.84±1.69	19.02±0.10	0.094±0.003
K0T30	67.86±0.66	0.978±0.008	131.85±2.97	19.76±0.75	0.095±0.003
K1T0	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

Note~~B~~: 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[a]	0.976±0.01[b]	128.36±3.30[a]	19.23±0.55[d]	0.097±0.097[a]
K1	68.20±0.74[a]	0.971±0.01[a]	133.58±8.42[b]	18.93±0.34[c]	0.112±0.111[b]
K2	68.89±0.73[b]	0.970±0.01[a]	137.62±6.05[b]	18.48±0.23[b]	0.141±0.139[c]
K3	69.52±0.73[c]	0.971±0.01[a]	159.11±6.77[c]	17.96±0.40[a]	0.173±0.171[d]

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, $p \leq 0.05$.



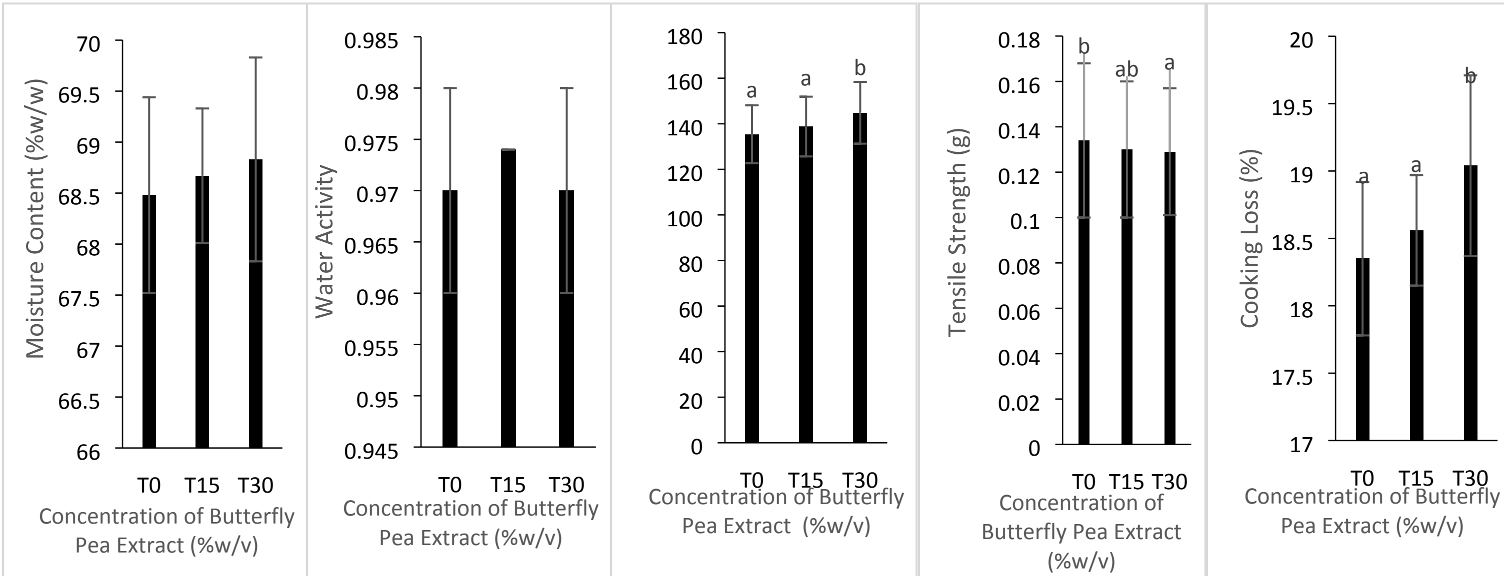
~~(a) (b) (c) (d) (e)~~

~~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 ≤ 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[a]	18.35±0.57[a]	0.134±0.034[b]
T15	68.67±0.66	0.974±0.000	138.77±13.12[a]	18.56±0.41[a]	0.130±0.030[ab]
T30	68.83±1.00	0.970±0.010	144.82±13.55[b]	19.04±0.67[b]	0.129±0.028[a]

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, $p \leq 0.05$.



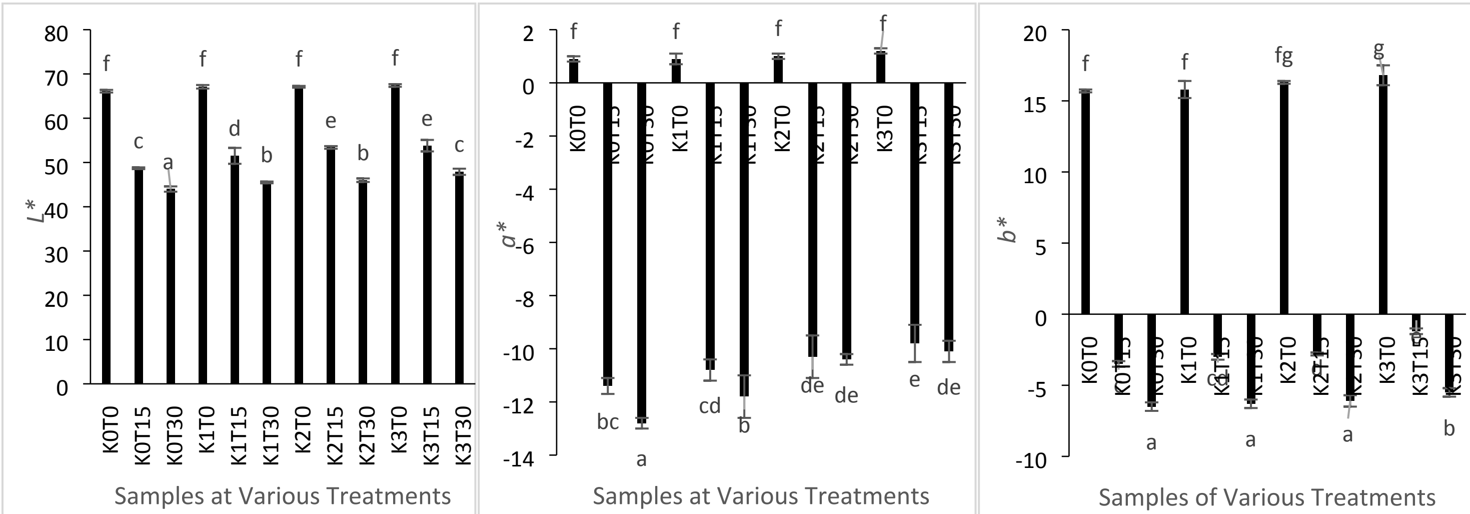
(a) (b) (c) (d) (e)

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, $p \leq 0.05$.

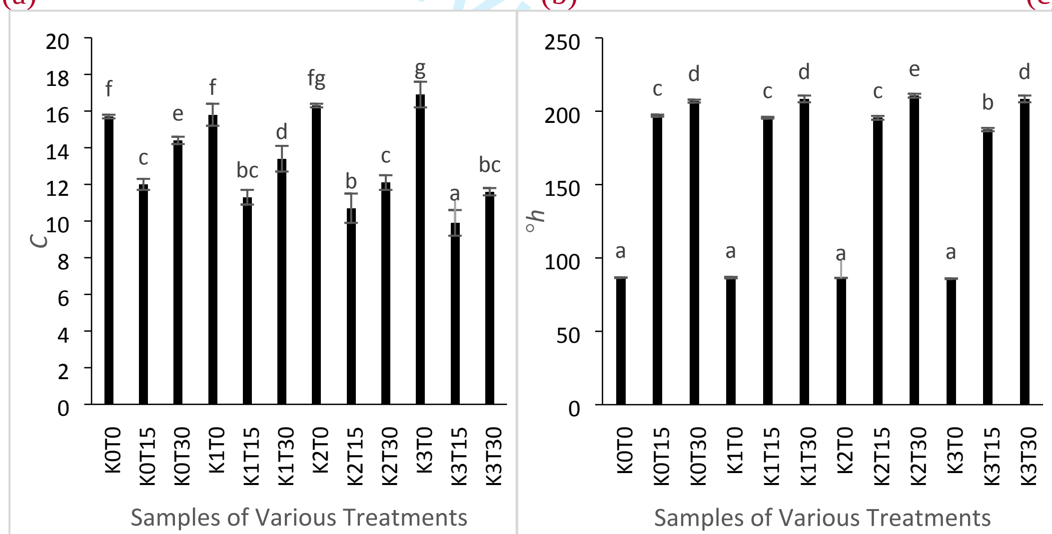
Table 5. Effect of interaction between composite flour and butterfly pea extract on wet noodle's color

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

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, $p \leq 0.05$.


L*
a*
b*
K0T0 K0T15 K0T30 K1T0 K1T15 K1T30 K2T0 K2T15 K2T30 K3T0 K3T15 K3T30
Samples at Various Treatments
Samples at Various Treatments
Samples of Various Treatments

(a) (b) (c)


C
°h
K0T0 K0T15 K0T30 K1T0 K1T15 K1T30 K2T0 K2T15 K2T30 K3T0 K3T15 K3T30
Samples of Various Treatments
Samples of Various Treatments

(d) (f)

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, $p \leq 0.05$.

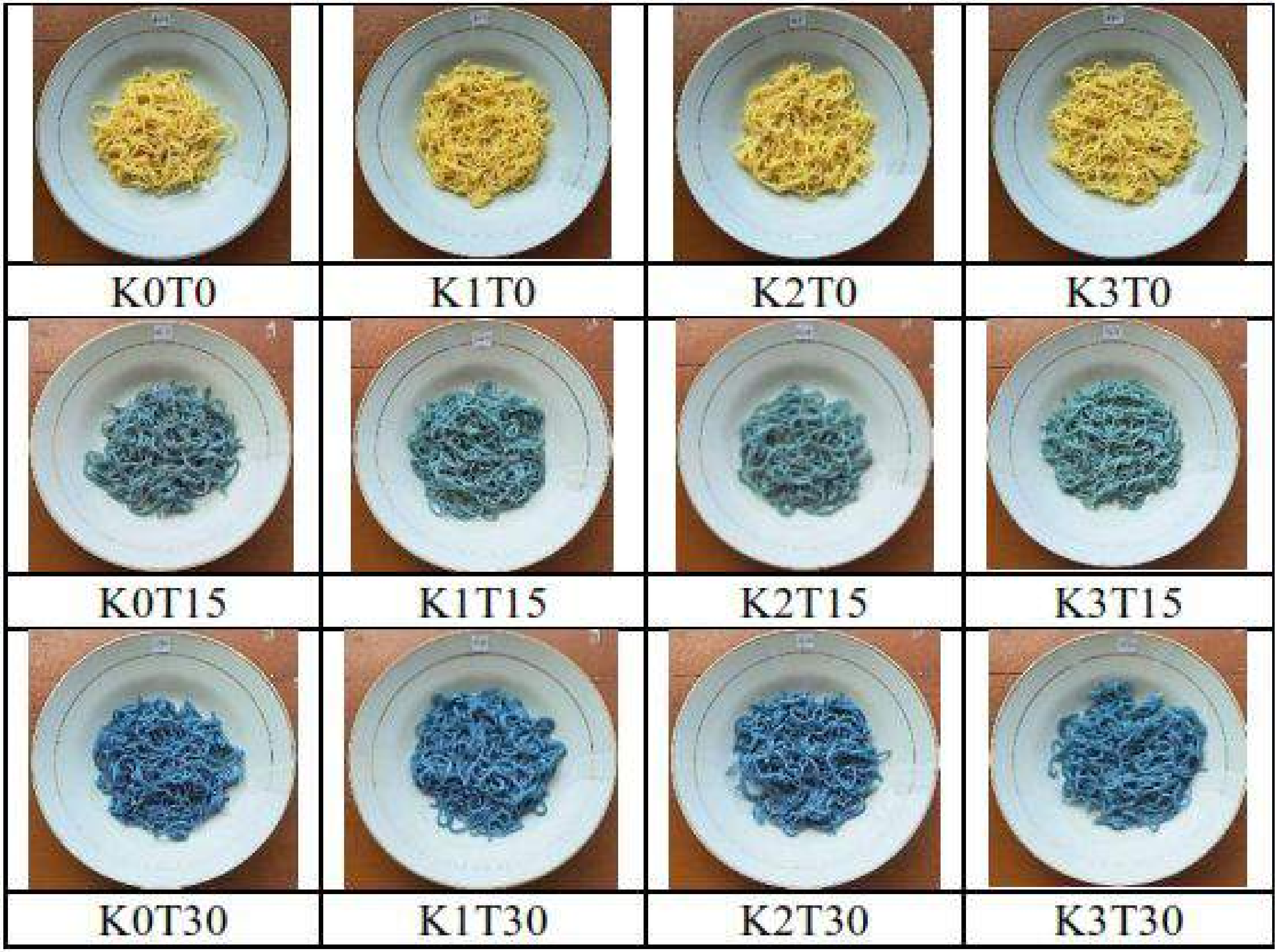
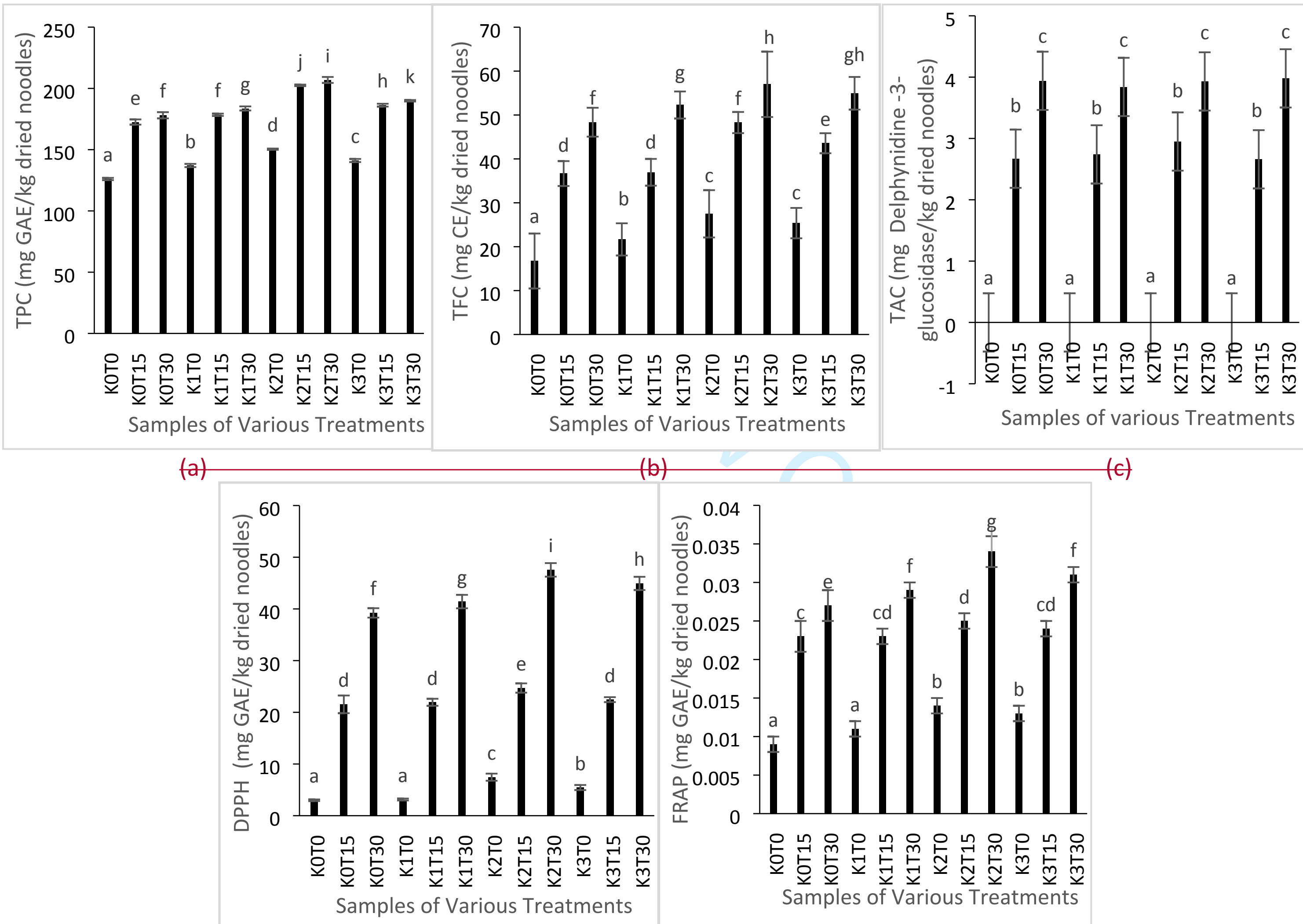

K0T0
K1T0
K2T0
K3T0
K0T15
K1T15
K2T15
K3T15
K0T30
K1T30
K2T30
K3T30

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

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, $p \leq 0.05$.


TPC (mg GAE/kg dried noodles)
Samples of Various Treatments
(a)
TFC (mg CE/kg dried noodles)
Samples of Various Treatments
(b)
TAC (mg Delphynidine -3-glucosidase/kg dried noodles)
Samples of various Treatments
(c)
DPPH (mg GAE/kg dried noodles)
Samples of Various Treatments
FRAP (mg GAE/kg dried noodles)
Samples of Various Treatments
K0T0 K0T15 K0T30 K1T0 K1T15 K1T30 K2T0 K2T15 K2T30 K3T0 K3T15 K3T30

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

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, $p \leq 0.05$.

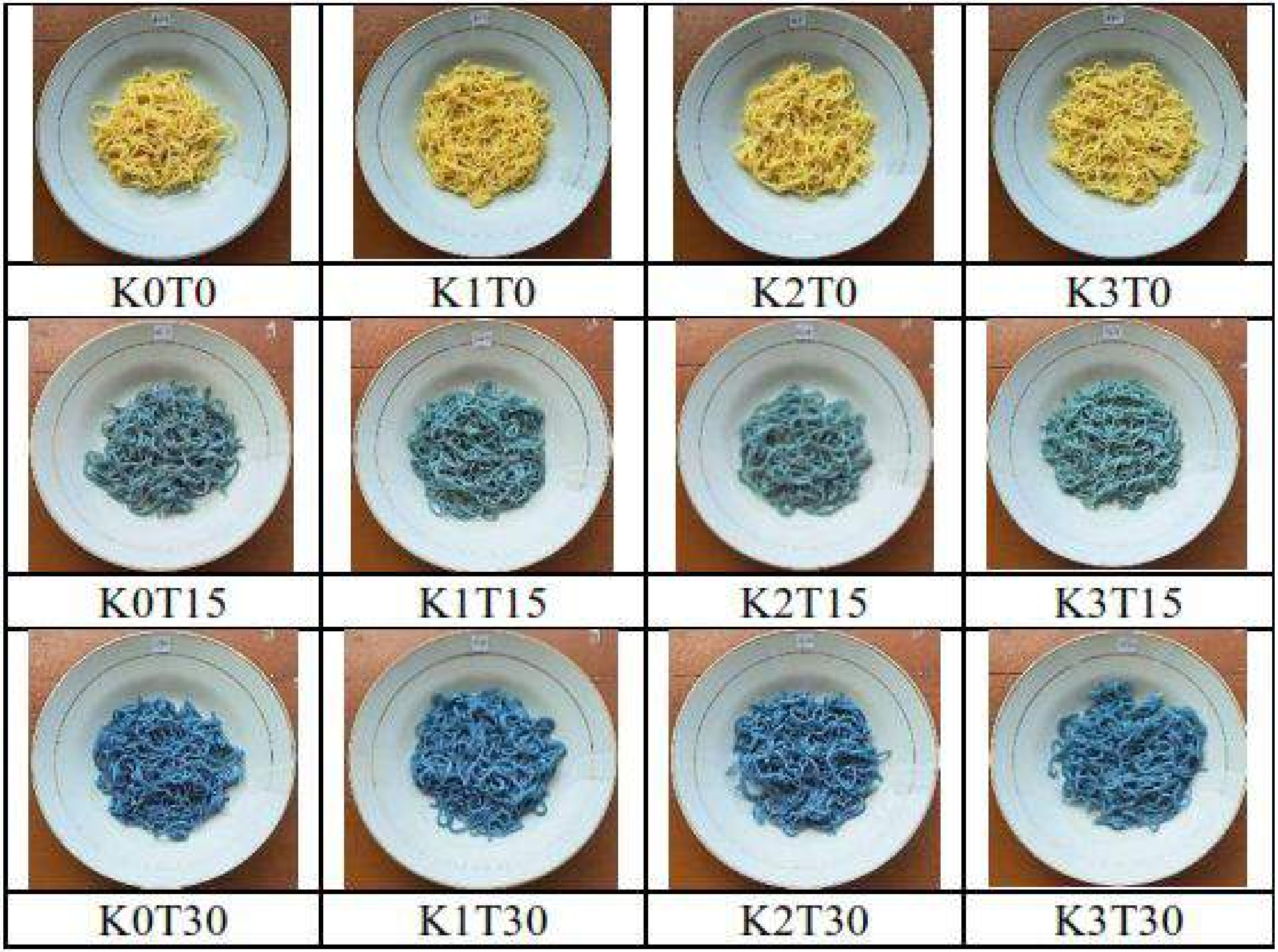


Figure 1. Color of wet noodles at various proportions of composite flour and concentrations of butterfly pea flower extract

Table 1. Formula of wet noodles

Treatment	Code	Ingredients				
		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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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
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
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K0T30	8.93±3.50^{bc}	7.71±3.76^{c}	9.26±3.17^{bcd}	11.13±3.09^{a}	0.6691
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K1T15	9.98±3.06^{bc}	8.40±3.28^{c}	10.16±2.59^{def}	10.61±2.82^{ab}	0.7086
K1T30	10.08±3.28^{bc}	9.10±3.08^{c}	10.44±2.32^{bcd}	10.36±2.81^{ab}	0.7389
K2T0	10.41±3.01^{a}	9.39±3.27^{ab}	11.04±2.44^{ab}	10.55±2.60^{cde}	0.3969
K2T15	10.8±2.85^{bc}	9.26±3.10^{c}	10.11±2.76^{f}	10.89±2.65^{abcd}	0.9219
K2T30	10.73±3.02^{c}	9.10±3.46^{c}	9.85±2.99^{def}	10.16±2.74^{abc}	0.9112
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K3T15	10.91±3.23^{bc}	9.48±3.56^{c}	10.45±2.82^{cde}	10.49±2.68^{bcde}	0.9235
K3T30	10.88±3.14^{c}	9.49±3.59^{c}	10.81±2.74^{ef}	10.86±2.60^{bcde}	**1.0504**

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, $p \leq 0.05$.

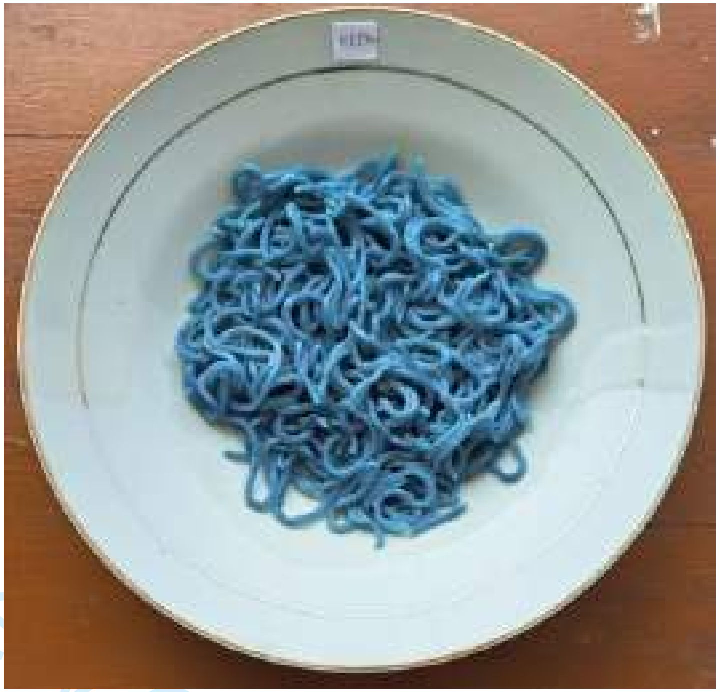
K0T0

K0T15

K0T30

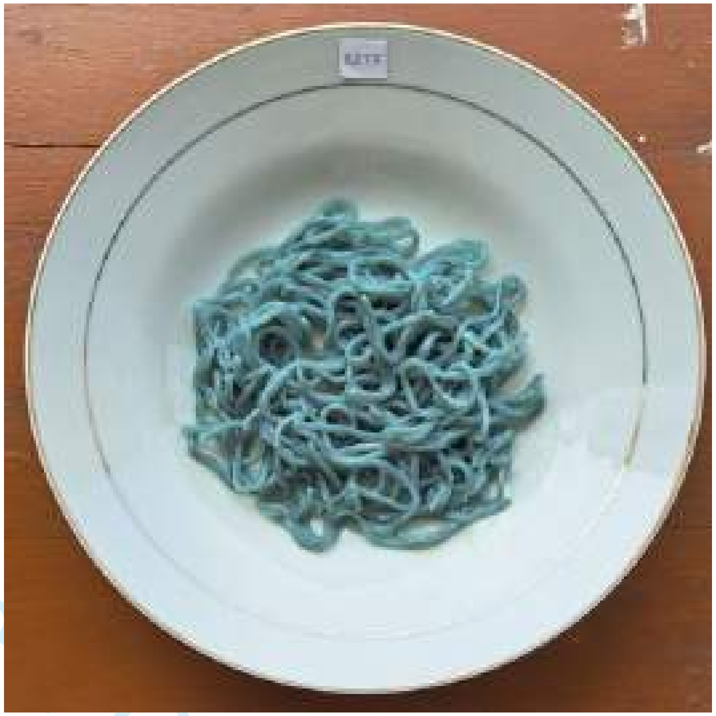
K1T0

K1T15



K1T30

K2T0



K2T15

K2T30

K3T0

Gmail

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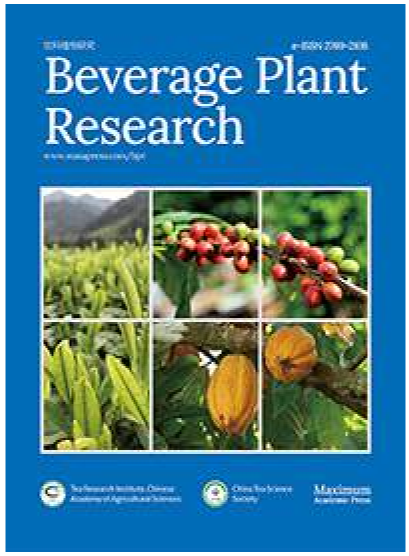

Effect of butterfly pea (Clitoria ternatea) flower extract to qualities, sensory properties, and antioxidant activity of wet noodles with various composite flour proportions

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

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

The improvement of wet noodles' qualities, sensory, and functional properties was made by using the composite flour base added with the butterfly pea flower extract. The composite flour consisted of wheat flour and stink lily flour, and κ-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 the 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 κ-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-κ-carrageenan at a ratio of 80:17:3 (% w/w) had the highest consumer acceptance based on hedonic sensory score.

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

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· [1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al. [2] 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 [3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al. [4] 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. [5,6]. Widyawati et al. [7] explained that using the composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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. [8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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 an herb plant from the Fabaceae family with various flower colors, such as purple, blue, pink, and white [9]. This flower has phytochemical compounds that benefit as antioxidant sources [10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides [12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products [14,15], one of them is wet noodles [16,17]. 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 [18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility [19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa* Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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 ^{o}C for 3 min based on the modified method of Widyawati et al. [20] and Purwanto et al. [24] to get 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 κ-carrageenan (Sigma-Aldrich, St. Louis, MO, USA). Indonesia) at ratios of 80:20:0 (K0), 80:19:1 (K1), 80:18:2 (K2), and 80:17:3 (K3) (% w/w).

Chemical 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 noodles preparation

Wet noodles were prepared based on the modified formula of Panjaitan et al. [25], 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 get 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 heated in boiled water (100 ^{o}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.[7]. Raw noodles were dried in a cabinet dryer (Gas drying oven machine OVG-6 SS, PT Agrowindo, Indonesia) at 60 ^{o}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 ^{o}C for 1 h, and centrifuged at 5000 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 ^{o}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 [26]. About 1 g of the sample was weighed in a weighing bottle and heated in a drying oven at 105-110 ^{o}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 [27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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 mm/s, 3 mm, and 10 mm/s, respectively. Distance, time, and trigger force were set to 100 mm, 5 sec, 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.[29]. The parameters measured were lightness (*L**), redness (*a**), yellowness (*b**), Hue (^{o}h), and chroma (C). *L** value ranged from 0-100 expresses brightness, and *a** value shows red color with an interval between -80 - +100. *b** value represents a yellow color with an interval of -70 - +70 [30]. *C* indicates the color intensity and ^{o}h states the color of samples [31].

Swelling index analysis

The swelling index was determined using a modified method by Islamiya et al.[32]. Approximately 5 g of the raw wet noodles were weighed in a chamber and cooked in 150 mL boiled water (100 ^{o}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 [33]. 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 by Aditia et al. [34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick [35]. About 5 g of the raw wet noodles was weighed in a chamber and cooked in 150 mL boiled water (100 ^{o}C) for 5 min. Then, the sample was drained and dried in a drying oven at 105 ^{o}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 Eyele et al. [36]. About 50 μL 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 % Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ 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 = [(As-0.0287)/0.0004][2 mL/x g][1L/1000mL][1000g/1kg], 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 by Li et al. [37]. The procedure began with mixing 0.3 mL of 5 % $NaNO_2$ and 250 µL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10 % $AlCl_3$ 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 λ. 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 = [(As-0.0014)/0.0008][2 mL/x g][1L/1000mL][1000g/1kg], 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 and Wrolstad [38]. About 250 µL 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 λ 543 and 700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = $(A\lambda 543 - A\lambda 700)pH\,1.0 - (A\lambda 543 - A\lambda 700)pH4.5$. The total anthocyanin monomer content (TA) (mg/mL) was calculated with the formula: $\frac{AxMWxDFx1000}{\varepsilon\, x\, l}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g/mol), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29000 L cm^{-1} mol^{-1}). TA monomer (mg delphinidine-3-glucoside/kg dried noodles) was calculated using the equation= [TA (mg/L)] [2mL/x g][1L/1000mL][1000g/1kg], 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. [39] and Widyawati et al. [40]. Briefly, 10 µL 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 5000 rpm for 5 min, and the absorbance of samples was measured at λ 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) (%) = [(A0-As)/A0]x 100%, where A0= absorbance of the control and As=absorbance of the samples. DPPH free radical scavenging activity (mg GAE/kg dried noodles) = [(y-2.4741)/0.1405] [2mL/x g][1L/1000mL][1000g/1kg], where x=the weight of dried noodles.

Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi and Choundhary [41]. Approximately 50 µL 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 ^{o}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 λ 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:

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

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

Sensory evaluation

The sensory properties of cooked wet noodles were analyzed based on Nugroho et al.[42] 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 dislike, and 15 was very 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 twelve (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 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 like it. The best treatment was determined by the index effectiveness test [43]. 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 determining of 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)

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 x 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 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 κ-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 three replications. The homogenous triplicate data were expressed as the mean ± SD. The one-way analysis of variance (ANOVA) was done, 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 Table 2, 3, 4, dan 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 ($p \leqslant 0.05$) (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 ($p \leqslant 0.05$) (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 κ-carrageenan. An increase of κ-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 [7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules [44]. The glucomannan of stinky lily flour can form a secondary structure with sulfhydryl groups of gluten network to stabilize the gluten network, increasing water binding capacity and retarding the migration of water molecules [45]. κ-carrageenan can bind water molecules around 25-40 times [46]. The κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding [47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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 composite flour significantly influenced the amount of free water ($p \leqslant 0.05$) (Table 3). The addition of κ-carrageenan between 1-3 % in the wet noodle formulation reduced the A_w by about 0.005-0.006. The capability of κ-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 [48]. 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 ($p \leq 0.05$) (Table 3 and 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 κ-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 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 glutelin, gliadin, glucomannan, κ-carrageenan, and polyphenolic compounds, which resulted in a three-dimensional network structure that determined the capability of the noodle strands being resistance to break and gel formation. κ-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 α-(1,3) and β-(1,4) glycosidic linkages [49] that can bind water molecule to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times [50] to form a strong gel that increases the viscosity and swelling index of the dough [51]. Park and Baik [52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al. [48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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 [54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] and Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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 [19,20,56].

The color of wet noodles (Table 5 and 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 ^{o}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 ^{o}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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Masakuni and Konishi[57] reported that κ-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. Gamage et al.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-carrageenan, that could reduce the intensity of blue color or chroma values.

The phenolic (TPC), total flavonoid (TFC), and total anthocyanin (TAC) contents 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 κ-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±0.18 mg delfidine-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). 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 [60], around 2.41 mg/g samples [61] that has free more acyl groups and aglycone structure [62] 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 [63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose) [12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids [62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity [10,64]. *Clitoria ternatea* shows to exhibit 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^{2+} reducing power assays [64]. 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. [65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus’s phenol reagent. Devaraj et al. [66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18 and 2 % (w/w) of stinky lily flour and κ-carrageenan and 15 % (w/w) of extract. However, the use of 17 and 3 % (w/w) of stinky lily flour and κ-carrageenan and 30 % (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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 them 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[67]. Poli et al.[68] stated that bioactive compounds acted as DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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.[72] 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 doubles 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.[67] 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 additions 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.[42] also informed 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. [73] claimed that oxalic acid contained in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini and Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al. [63] 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.[75] 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[76], 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 and

Kumalasari [77]. The effect of composite flour proportion and butterfly pea extract addition also appeared to 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 [18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel [78]. 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 κ-carrageenan and butterfly pea extract in wet noodle making influenced wet noodles' quality, bioactive compounds, antioxidant activity, and sensory properties. Interaction among glutelin, gliadin, amylose, glucomannan, κ-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 extracts improved color, bioactive content, and antioxidant activity and enhanced panelist preference for wet noodles. Glucomannan of stinky lily flour and bioactive compounds of butterfly pea extract increased the functional value of resulting wet noodles.

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Conflict of Interest

The authors declare no conflict of interest

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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: κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour: stink lily flour: κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour: stink lily flour: κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour: stink lily flour: κ-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

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[a]	0.976±0.01[b]	128.36±3.30[a]	19.23±0.55[d]	0.097±0.097[a]
K1	68.20±0.74[a]	0.971±0.01[a]	133.58±8.42[b]	18.93±0.34[c]	0.112±0.111[b]
K2	68.89±0.73[b]	0.970±0.01[a]	137.62±6.05[b]	18.48±0.23[b]	0.141±0.139[c]
K3	69.52±0.73[c]	0.971±0.01[a]	159.11±6.77[c]	17.96±0.40[a]	0.173±0.171[d]

Note: All of the data showed that there was a significant effect of composite flour on the quality properties of wet noodles at $p \leqslant 0.05$. 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, $p \leqslant 0.05$.

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[a]	18.35±0.57[a]	0.134±0.034[b]
T15	68.67±0.66	0.974±0.000	138.77±13.12[a]	18.56±0.41[a]	0.130±0.030[ab]
T30	68.83±1.00	0.970±0.010	144.82±13.55[b]	19.04±0.67[b]	0.129±0.028[a]

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 $p \leqslant 0.05$. 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	*L**	*a**	*b**	*C*	^{o}h
K0T0	66.10±0.30^{f}	0.90±0.10^{f}	15.70±0.10^{f}	15.70±0.10^{f}	86.60±0.20^{a}
K0T15	48.70±0.20^{c}	-11.40±0.30^{bc}	-3.50±0.20^{c}	12.00±0.30^{c}	197.00±0.70^{c}
K0T30	44.00±0.60^{a}	-12.80±0.20^{a}	-6.50±0.30^{a}	14.40±0.20^{e}	206.90±1.00^{d}
K1T0	67.10±0.40^{f}	0.90±0.20^{f}	15.80±0.60^{f}	15.80±0.60^{f}	86.60±0.50^{a}
K1T15	51.50±1.80^{d}	-10.80±0.40^{cd}	-3.00±0.20^{cd}	11.30±0.40^{bc}	195.60±0.60^{c}
K1T30	45.50±0.20^{b}	-11.80±0.80^{b}	-6.30±0.30^{a}	13.40±0.70^{d}	208.40±2.30^{d}
K2T0	67.10±0.20^{f}	1.00±0.10^{f}	16.30±0.10^{fg}	16.30±0.10^{fg}	86.40±0.10^{a}
K2T15	53.40±0.30^{e}	-10.30±0.80^{de}	-2.80±0.10^{d}	10.70±0.80^{b}	195.50±1.30^{c}
K2T30	46.00±0.40^{b}	-10.40±0.20^{de}	-6.10±0.40^{a}	12.10±0.40^{c}	210.60±1.30^{e}
K3T0	67.40±0.30^{f}	1.20±0.10^{f}	16.80±0.70^{g}	16.90±0.70^{g}	85.90±0.20^{a}
K3T15	53.80±1.30^{e}	-9.80±0.70^{e}	-1.20±0.20^{e}	9.90±0.70^{a}	187.50±1.10^{b}
K3T30	47.90±0.70^{c}	-10.10±0.40^{de}	-5.50±0.30^{b}	11.60±0.20^{bc}	208.40±2.30^{d}

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 $p \leqslant 0.05$. 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, $p \leq 0.05$.

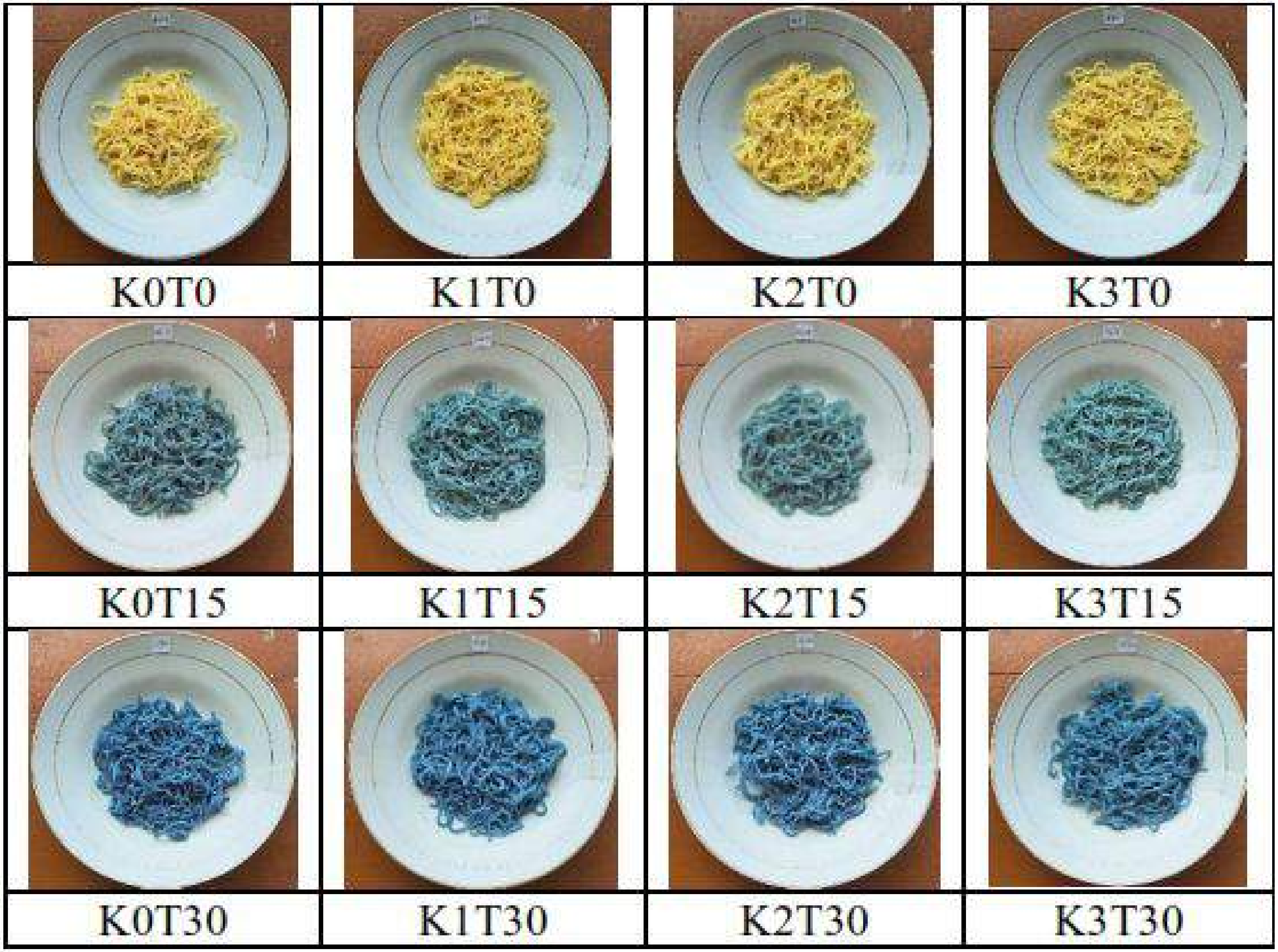

Figure 1. Color of wet noodles at various proportions of composite flour and concentrations of butterfly pea flower extract

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

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

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, $p \leq 0.05$.

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Beverage Plant Research **2024**, in press

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 κ-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 κ-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-κ-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. [1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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.[20] and Purwanto et al.[24] 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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (L^*), redness (a^*), yellowness (b^*), hue (^oh), 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[30]. C indicates the color intensity and ^oh states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 µL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ 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:

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

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.[37] The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 µL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ510 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:

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

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[38] About 250 µL 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 λ543 and λ700 nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = (Aλ543 − Aλ700)pH1.0 − (Aλ543 − Aλ700)pH4.5. The total anthocyanin monomer content (TA) (mg·mL^{-1}) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g·mol^{-1}), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 L·cm^{-1}·mol^{-1}).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 µL 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 λ517 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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where A0 = absorbance of the control and As = absorbance of the samples.

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

where x = the weight of dried noodles.

Ferric reducing antioxidant power

FRAP analysis was performed using the modified method of Al-Temimi & Choundhary[41]. Approximately 50 µL 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 λ 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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25−40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^a	0.976 ± 0.01^b	128.36 ± 3.30^a	19.23 ± 0.55^d	0.097 ± 0.097^a
K1	68.20 ± 0.74^a	0.971 ± 0.01^a	133.58 ± 8.42^b	18.93 ± 0.34^c	0.112 ± 0.111^b
K2	68.89 ± 0.73^b	0.970 ± 0.01^a	137.62 ± 6.05^b	18.48 ± 0.23^b	0.141 ± 0.139^c
K3	69.52 ± 0.73^c	0.971 ± 0.01^a	159.11 ± 6.77^c	17.96 ± 0.40^a	0.173 ± 0.171^d

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^a	18.35 ± 0.57^a	0.134 ± 0.034^b
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^a	18.56 ± 0.41^a	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^b	19.04 ± 0.67^b	0.129 ± 0.028^a

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 κ-carrageenan between 1%−3% in the wet noodle formulation reduced the A_w by about 0.005–0.006. The capability of κ-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[48]. 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.

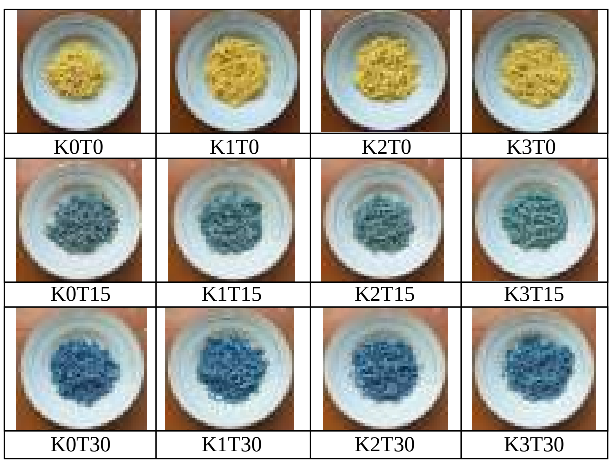

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 ^oh 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 ^oh 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-

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

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

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. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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[a]	16.74 ± 6.26[a]	0.00 ± 0.00[a]	2.99 ± 0.16[a]	0.009 ± 0.001[a]
K0T15	172.57 ± 2.14[e]	36.66 ± 2.84[d]	2.67 ± 0.21[b]	21.54 ± 1.71[d]	0.023 ± 0.002[c]
K0T30	178.07 ± 2.54[f]	48.36 ± 3.29[f]	3.94 ± 0.28[c]	39.23 ± 0.91[f]	0.027 ± 0.002[e]
K1T0	137.07 ± 1.32[b]	21.66 ± 3.67[b]	0.00 ± 0.00[a]	3.13 ± 0.19[a]	0.011 ± 0.001[a]
K1T15	178.48 ± 0.95[f]	36.95 ± 3.05[d]	2.74 ± 0.21[b]	21.94 ± 0.68[d]	0.023 ± 0.001[cd]
K1T30	183.65 ± 1.67[g]	52.28 ± 3.08[g]	3.84 ± 0.19[c]	41.42 ± 1.30[g]	0.029 ± 0.001[f]
K2T0	150.40 ± 0.52[d]	27.49 ± 5.39[c]	0.00 ± 0.00[a]	7.45 ± 0.69[c]	0.014 ± 0.001[b]
K2T15	202.48 ± 0.63[j]	48.28 ± 2.41[f]	2.95 ± 0.57[b]	24.70 ± 0.90[e]	0.025 ± 0.001[d]
K2T30	206.90 ± 2.43[i]	56.99 ± 7.45[h]	3.93 ± 0.42[c]	47.55 ± 1.31[i]	0.034 ± 0.002[g]
K3T0	141.15 ± 1.28[c]	25.37 ± 3.46[c]	0.00 ± 0.00[a]	5.45 ± 0.49[b]	0.013 ± 0.001[b]
K3T15	186.32 ± 1.15[h]	43.57 ± 2.28[e]	2.66 ± 0.21[b]	22.45 ± 0.48[d]	0.024 ± 0.001[cd]
K3T30	189.90 ± 0.63[k]	54.95 ± 3.72[gh]	3.98 ± 0.37[c]	44.93 ± 1.28[h]	0.031 ± 0.001[f]

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[60], around 2.41 mg/g samples[61] that has freed more acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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^{a}	7.41 ± 3.80^{a}	8.71 ± 3.16^{a}	10.78 ± 2.86^{abcde}	0.1597
K0T15	8.96 ± 3.38^{b}	7.75 ± 3.89^{b}	9.35 ± 3.36^{cde}	11.19 ± 3.10^{abcd}	0.6219
K0T30	8.93 ± 3.50^{bc}	7.71 ± 3.76^{c}	9.26 ± 3.17^{bcd}	11.13 ± 3.09^{a}	0.6691
K1T0	8.74 ± 3.62^{a}	8.13 ± 3.56^{ab}	9.58 ± 3.13^{ab}	11.33 ± 3.12^{de}	0.4339
K1T15	9.98 ± 3.06^{bc}	8.40 ± 3.28^{c}	10.16 ± 2.59^{def}	10.61 ± 2.82^{ab}	0.7086
K1T30	10.08 ± 3.28^{bc}	9.10 ± 3.08^{c}	10.44 ± 2.32^{bcd}	10.36 ± 2.81^{ab}	0.7389
K2T0	10.41 ± 3.01^{a}	9.39 ± 3.27^{ab}	11.04 ± 2.44^{ab}	10.55 ± 2.60^{cde}	0.3969
K2T15	10.8 ± 2.85^{bc}	9.26 ± 3.10^{c}	10.11 ± 2.76^{f}	10.89 ± 2.65^{abcd}	0.9219
K2T30	10.73 ± 3.02^{c}	9.10 ± 3.46^{c}	9.85 ± 2.99^{def}	10.16 ± 2.74^{abc}	0.9112
K3T0	10.73 ± 3.42^{a}	9.19 ± 3.38^{b}	9.93 ± 2.50^{bc}	10.34 ± 2.84^{e}	0.5249
K3T15	10.91 ± 3.23^{bc}	9.48 ± 3.56^{c}	10.45 ± 2.82^{cde}	10.49 ± 2.68^{bcde}	0.9235
K3T30	10.88 ± 3.14^{c}	9.49 ± 3.59^{c}	10.81 ± 2.74^{ef}	10.86 ± 2.60^{bcde}	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 complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.[72] 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 doubles 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.[67] 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.[42] 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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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 κ-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 κ-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-κ-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.[1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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.[20] and Purwanto et al.[2[illegible]] [illegible]obtain three concentrations of butterfly pea extract: 0 (T1[illegible] (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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (*L**), redness (*a**), yellowness (*b**), hue (°*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[30]. *C* indicates the color intensity and °*h* states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 μL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ_{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:

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

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.[37] The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 μL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ_{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:

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

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[38] About 250 μL 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 λ_{543} and λ_{700} nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = $(A\lambda_{543} - A\lambda_{700})$pH1.0 − $(A\lambda_{543} - A\lambda_{700})$pH4.5. The total anthocyanin monomer content (TA) ($mg \cdot mL^{-1}$) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 $g \cdot mol^{-1}$), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 $L \cdot cm^{-1} \cdot mol^{-1}$).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 μL 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 λ_{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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where A0 = absorbance of the control and As = 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[41]. Approximately 50 μL 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 λ_{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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25−40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^a	0.976 ± 0.01^b	128.36 ± 3.30^a	19.23 ± 0.55^d	0.097 ± 0.097^a
K1	68.20 ± 0.74^a	0.971 ± 0.01^a	133.58 ± 8.42^b	18.93 ± 0.34^c	0.112 ± 0.111^b
K2	68.89 ± 0.73^b	0.970 ± 0.01^a	137.62 ± 6.05^b	18.48 ± 0.23^b	0.141 ± 0.139^c
K3	69.52 ± 0.73^c	0.971 ± 0.01^a	159.11 ± 6.77^c	17.96 ± 0.40^a	0.173 ± 0.171^d

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^a	18.35 ± 0.57^a	0.134 ± 0.034^b
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^a	18.56 ± 0.41^a	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^b	19.04 ± 0.67^b	0.129 ± 0.028^a

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 κ-carrageenan between 1%–3% in the wet noodle formulation reduced the A_w by about 0.005–0.006. The capability of κ-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[48]. 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.

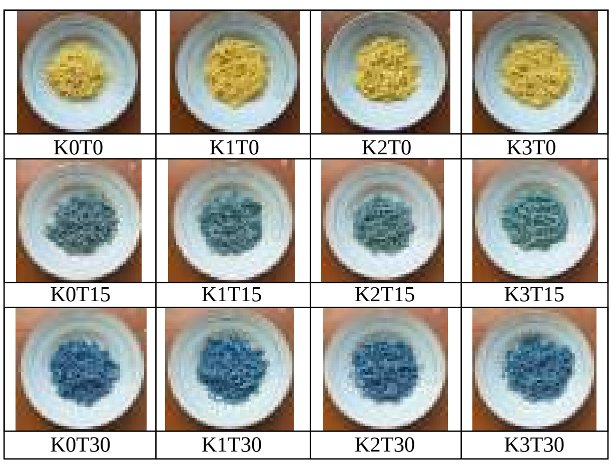

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 $°h$ 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 $°h$ 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-

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

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

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. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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^{a}	16.74 ± 6.26^{a}	0.00 ± 0.00^{a}	2.99 ± 0.16^{a}	0.009 ± 0.001^{a}
K0T15	172.57 ± 2.14^{e}	36.66 ± 2.84^{d}	2.67 ± 0.21^{b}	21.54 ± 1.71^{d}	0.023 ± 0.002^{c}
K0T30	178.07 ± 2.54^{f}	48.36 ± 3.29^{f}	3.94 ± 0.28^{c}	39.23 ± 0.91^{f}	0.027 ± 0.002^{e}
K1T0	137.07 ± 1.32^{b}	21.66 ± 3.67^{b}	0.00 ± 0.00^{a}	3.13 ± 0.19^{a}	0.011 ± 0.001^{a}
K1T15	178.48 ± 0.95^{f}	36.95 ± 3.05^{d}	2.74 ± 0.21^{b}	21.94 ± 0.68^{d}	0.023 ± 0.001^{cd}
K1T30	183.65 ± 1.67^{g}	52.28 ± 3.08^{g}	3.84 ± 0.19^{c}	41.42 ± 1.30^{g}	0.029 ± 0.001^{f}
K2T0	150.40 ± 0.52^{d}	27.49 ± 5.39^{c}	0.00 ± 0.00^{a}	7.45 ± 0.69^{c}	0.014 ± 0.001^{b}
K2T15	202.48 ± 0.63^{j}	48.28 ± 2.41^{f}	2.95 ± 0.57^{b}	24.70 ± 0.90^{e}	0.025 ± 0.001^{d}
K2T30	206.90 ± 2.43^{i}	56.99 ± 7.45^{h}	3.93 ± 0.42^{c}	47.55 ± 1.31^{i}	0.034 ± 0.002^{g}
K3T0	141.15 ± 1.28^{c}	25.37 ± 3.46^{c}	0.00 ± 0.00^{a}	5.45 ± 0.49^{b}	0.013 ± 0.001^{b}
K3T15	186.32 ± 1.15^{h}	43.57 ± 2.28^{e}	2.66 ± 0.21^{b}	22.45 ± 0.48^{d}	0.024 ± 0.001^{cd}
K3T30	189.90 ± 0.63^{k}	54.95 ± 3.72^{gh}	3.98 ± 0.37^{c}	44.93 ± 1.28^{h}	0.031 ± 0.001^{f}

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[60], around 2.41 mg/g samples[61] that has more free acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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^{a}	7.41 ± 3.80^{a}	8.71 ± 3.16^{a}	10.78 ± 2.86^{abcde}	0.1597
K0T15	8.96 ± 3.38^{b}	7.75 ± 3.89^{b}	9.35 ± 3.36^{cde}	11.19 ± 3.10^{abcd}	0.6219
K0T30	8.93 ± 3.50^{bc}	7.71 ± 3.76^{c}	9.26 ± 3.17^{bcd}	11.13 ± 3.09^{a}	0.6691
K1T0	8.74 ± 3.62^{a}	8.13 ± 3.56^{ab}	9.58 ± 3.13^{ab}	11.33 ± 3.12^{de}	0.4339
K1T15	9.98 ± 3.06^{bc}	8.40 ± 3.28^{c}	10.16 ± 2.59^{def}	10.61 ± 2.82^{ab}	0.7086
K1T30	10.08 ± 3.28^{bc}	9.10 ± 3.08^{c}	10.44 ± 2.32^{bcd}	10.36 ± 2.81^{ab}	0.7389
K2T0	10.41 ± 3.01^{a}	9.39 ± 3.27^{ab}	11.04 ± 2.44^{ab}	10.55 ± 2.60^{cde}	0.3969
K2T15	10.8 ± 2.85^{bc}	9.26 ± 3.10^{c}	10.11 ± 2.76^{f}	10.89 ± 2.65^{abcd}	0.9219
K2T30	10.73 ± 3.02^{c}	9.10 ± 3.46^{c}	9.85 ± 2.99^{def}	10.16 ± 2.74^{abc}	0.9112
K3T0	10.73 ± 3.42^{a}	9.19 ± 3.38^{b}	9.93 ± 2.50^{bc}	10.34 ± 2.84^{e}	0.5249
K3T15	10.91 ± 3.23^{bc}	9.48 ± 3.56^{c}	10.45 ± 2.82^{cde}	10.49 ± 2.68^{bcde}	0.9235
K3T30	10.88 ± 3.14^{c}	9.49 ± 3.59^{c}	10.81 ± 2.74^{ef}	10.86 ± 2.60^{bcde}	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 $p \le 0.05$. 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, $p \le 0.05$.

tion or complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.[72] 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 doubles 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.[67] 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 ($p \le 0.05$) (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.[42]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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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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Neda GD, Rabeta MS, Ong MT. 2013. Chemical composition and anti-proliferative properties of flowers of *Clitoria Ternatea*. *International Food Research Journal* 20(3):1229−1234. Available online: http://www.ifrj.upm.edu.my/20%20(03)%202013/28%20IFRJ%2020%20(03)%202013%20Rabeta%20(389).pdf

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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.

Queries 16. Data Availability Statement

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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Beverage Plant Research **2024**, in press

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 κ-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 κ-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-κ-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. [1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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.[20] and Purwanto et al.[24] 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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (L^*), redness (a^*), yellowness (b^*), hue (°*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[30]. *C* indicates the color intensity and °*h* states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 µL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ_{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:

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

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.[37] The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 µL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ_{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:

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

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[38]. About 250 µL 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 λ_{543} and λ_{700} nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = $(A\lambda_{543} - A\lambda_{700})$pH1.0 − $(A\lambda_{543} - A\lambda_{700})$pH4.5. The total anthocyanin monomer content (TA) (mg·mL^{-1}) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g·mol^{-1}), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 L·cm^{-1}·mol^{-1}).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 µL 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 λ_{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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where A0 = absorbance of the control and As = 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[41]. Approximately 50 µL 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 λ_{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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25–40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^{a}	0.976 ± 0.01^{b}	128.36 ± 3.30^{a}	19.23 ± 0.55^{d}	0.097 ± 0.097^{a}
K1	68.20 ± 0.74^{a}	0.971 ± 0.01^{a}	133.58 ± 8.42^{b}	18.93 ± 0.34^{c}	0.112 ± 0.111^{b}
K2	68.89 ± 0.73^{b}	0.970 ± 0.01^{a}	137.62 ± 6.05^{b}	18.48 ± 0.23^{b}	0.141 ± 0.139^{c}
K3	69.52 ± 0.73^{c}	0.971 ± 0.01^{a}	159.11 ± 6.77^{c}	17.96 ± 0.40^{a}	0.173 ± 0.171^{d}

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^{a}	18.35 ± 0.57^{a}	0.134 ± 0.034^{b}
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^{a}	18.56 ± 0.41^{a}	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^{b}	19.04 ± 0.67^{b}	0.129 ± 0.028^{a}

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 κ-carrageenan between 1%−3% in the wet noodle formulation reduced the A_w by about 0.005–0.006. The capability of κ-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[48]. 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.

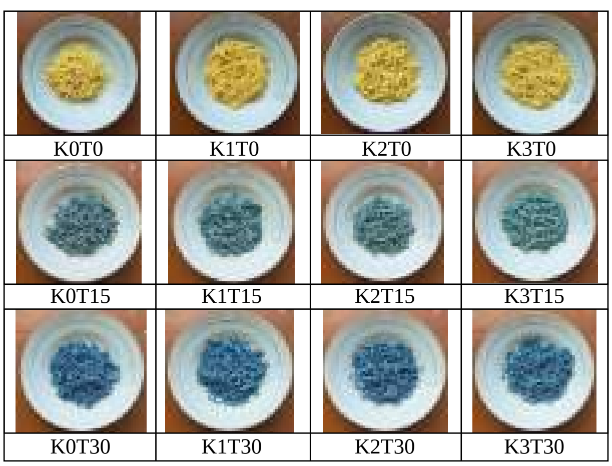

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 ^oh 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 ^oh 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-

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

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

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. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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[a]	16.74 ± 6.26[a]	0.00 ± 0.00[a]	2.99 ± 0.16[a]	0.009 ± 0.001[a]
K0T15	172.57 ± 2.14[e]	36.66 ± 2.84[d]	2.67 ± 0.21[b]	21.54 ± 1.71[d]	0.023 ± 0.002[c]
K0T30	178.07 ± 2.54[f]	48.36 ± 3.29[f]	3.94 ± 0.28[c]	39.23 ± 0.91[f]	0.027 ± 0.002[e]
K1T0	137.07 ± 1.32[b]	21.66 ± 3.67[b]	0.00 ± 0.00[a]	3.13 ± 0.19[a]	0.011 ± 0.001[a]
K1T15	178.48 ± 0.95[f]	36.95 ± 3.05[d]	2.74 ± 0.21[b]	21.94 ± 0.68[d]	0.023 ± 0.001[cd]
K1T30	183.65 ± 1.67[g]	52.28 ± 3.08[g]	3.84 ± 0.19[c]	41.42 ± 1.30[g]	0.029 ± 0.001[f]
K2T0	150.40 ± 0.52[d]	27.49 ± 5.39[c]	0.00 ± 0.00[a]	7.45 ± 0.69[c]	0.014 ± 0.001[b]
K2T15	202.48 ± 0.63[j]	48.28 ± 2.41[f]	2.95 ± 0.57[b]	24.70 ± 0.90[e]	0.025 ± 0.001[d]
K2T30	206.90 ± 2.43[i]	56.99 ± 7.45[h]	3.93 ± 0.42[c]	47.55 ± 1.31[i]	0.034 ± 0.002[g]
K3T0	141.15 ± 1.28[c]	25.37 ± 3.46[c]	0.00 ± 0.00[a]	5.45 ± 0.49[b]	0.013 ± 0.001[b]
K3T15	186.32 ± 1.15[h]	43.57 ± 2.28[e]	2.66 ± 0.21[b]	22.45 ± 0.48[d]	0.024 ± 0.001[cd]
K3T30	189.90 ± 0.63[k]	54.95 ± 3.72[gh]	3.98 ± 0.37[c]	44.93 ± 1.28[h]	0.031 ± 0.001[f]

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[60], around 2.41 mg/g samples[61] that has more free acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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^{a}	7.41 ± 3.80^{a}	8.71 ± 3.16^{a}	10.78 ± 2.86^{abcde}	0.1597
K0T15	8.96 ± 3.38^{b}	7.75 ± 3.89^{b}	9.35 ± 3.36^{cde}	11.19 ± 3.10^{abcd}	0.6219
K0T30	8.93 ± 3.50^{bc}	7.71 ± 3.76^{c}	9.26 ± 3.17^{bcd}	11.13 ± 3.09^{a}	0.6691
K1T0	8.74 ± 3.62^{a}	8.13 ± 3.56^{ab}	9.58 ± 3.13^{ab}	11.33 ± 3.12^{de}	0.4339
K1T15	9.98 ± 3.06^{bc}	8.40 ± 3.28^{c}	10.16 ± 2.59^{def}	10.61 ± 2.82^{ab}	0.7086
K1T30	10.08 ± 3.28^{bc}	9.10 ± 3.08^{c}	10.44 ± 2.32^{bcd}	10.36 ± 2.81^{ab}	0.7389
K2T0	10.41 ± 3.01^{a}	9.39 ± 3.27^{ab}	11.04 ± 2.44^{ab}	10.55 ± 2.60^{cde}	0.3969
K2T15	10.8 ± 2.85^{bc}	9.26 ± 3.10^{c}	10.11 ± 2.76^{f}	10.89 ± 2.65^{abcd}	0.9219
K2T30	10.73 ± 3.02^{c}	9.10 ± 3.46^{c}	9.85 ± 2.99^{def}	10.16 ± 2.74^{abc}	0.9112
K3T0	10.73 ± 3.42^{a}	9.19 ± 3.38^{b}	9.93 ± 2.50^{bc}	10.34 ± 2.84^{e}	0.5249
K3T15	10.91 ± 3.23^{bc}	9.48 ± 3.56^{c}	10.45 ± 2.82^{cde}	10.49 ± 2.68^{bcde}	0.9235
K3T30	10.88 ± 3.14^{c}	9.49 ± 3.59^{c}	10.81 ± 2.74^{ef}	10.86 ± 2.60^{bcde}	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 complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.[72] 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 doubles 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.[67] 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.[42]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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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 κ-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 κ-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-κ-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.[1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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.[20] and Purwanto et al.[24] 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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (L^*), redness (a^*), yellowness (b^*), hue (^oh), 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[30]. C indicates the color intensity and ^oh states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 μL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ_{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:

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

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.[37]. The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 μL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ_{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:

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

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[38]. About 250 μL 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 λ_{543} and λ_{700} nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = $(A\lambda_{543} - A\lambda_{700})$pH1.0 − $(A\lambda_{543} - A\lambda_{700})$pH4.5. The total anthocyanin monomer content (TA) (mg·mL⁻¹) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 g·mol^{-1}), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 L·cm^{-1}·mol^{-1}).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 μL 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 λ_{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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where A0 = absorbance of the control and As = 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[41]. Approximately 50 μL 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 λ_{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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25−40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^{a}	0.976 ± 0.01^{b}	128.36 ± 3.30^{a}	19.23 ± 0.55^{d}	0.097 ± 0.097^{a}
K1	68.20 ± 0.74^{a}	0.971 ± 0.01^{a}	133.58 ± 8.42^{b}	18.93 ± 0.34^{c}	0.112 ± 0.111^{b}
K2	68.89 ± 0.73^{b}	0.970 ± 0.01^{a}	137.62 ± 6.05^{b}	18.48 ± 0.23^{b}	0.141 ± 0.139^{c}
K3	69.52 ± 0.73^{c}	0.971 ± 0.01^{a}	159.11 ± 6.77^{c}	17.96 ± 0.40^{a}	0.173 ± 0.171^{d}

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^{a}	18.35 ± 0.57^{a}	0.134 ± 0.034^{b}
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^{a}	18.56 ± 0.41^{a}	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^{b}	19.04 ± 0.67^{b}	0.129 ± 0.028^{a}

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 κ-carrageenan between 1%–3% in the wet noodle formulation reduced the A_w by about 0.005–0.006. The capability of κ-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[48]. 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.

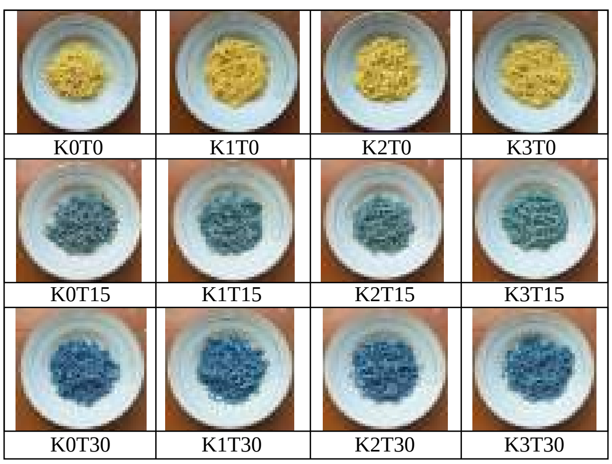

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 ^oh 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 ^oh 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-

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

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

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. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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[a]	16.74 ± 6.26[a]	0.00 ± 0.00[a]	2.99 ± 0.16[a]	0.009 ± 0.001[a]
K0T15	172.57 ± 2.14[e]	36.66 ± 2.84[d]	2.67 ± 0.21[b]	21.54 ± 1.71[d]	0.023 ± 0.002[c]
K0T30	178.07 ± 2.54[f]	48.36 ± 3.29[f]	3.94 ± 0.28[c]	39.23 ± 0.91[f]	0.027 ± 0.002[e]
K1T0	137.07 ± 1.32[b]	21.66 ± 3.67[b]	0.00 ± 0.00[a]	3.13 ± 0.19[a]	0.011 ± 0.001[a]
K1T15	178.48 ± 0.95[f]	36.95 ± 3.05[d]	2.74 ± 0.21[b]	21.94 ± 0.68[d]	0.023 ± 0.001[cd]
K1T30	183.65 ± 1.67[g]	52.28 ± 3.08[g]	3.84 ± 0.19[c]	41.42 ± 1.30[g]	0.029 ± 0.001[f]
K2T0	150.40 ± 0.52[d]	27.49 ± 5.39[c]	0.00 ± 0.00[a]	7.45 ± 0.69[c]	0.014 ± 0.001[b]
K2T15	202.48 ± 0.63[j]	48.28 ± 2.41[f]	2.95 ± 0.57[b]	24.70 ± 0.90[e]	0.025 ± 0.001[d]
K2T30	206.90 ± 2.43[i]	56.99 ± 7.45[h]	3.93 ± 0.42[c]	47.55 ± 1.31[i]	0.034 ± 0.002[g]
K3T0	141.15 ± 1.28[c]	25.37 ± 3.46[c]	0.00 ± 0.00[a]	5.45 ± 0.49[b]	0.013 ± 0.001[b]
K3T15	186.32 ± 1.15[h]	43.57 ± 2.28[e]	2.66 ± 0.21[b]	22.45 ± 0.48[d]	0.024 ± 0.001[cd]
K3T30	189.90 ± 0.63[k]	54.95 ± 3.72[gh]	3.98 ± 0.37[c]	44.93 ± 1.28[h]	0.031 ± 0.001[f]

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[60], around 2.41 mg/g samples[61] that has more free acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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[a]	7.41 ± 3.80[a]	8.71 ± 3.16[a]	10.78 ± 2.86[abcde]	0.1597
K0T15	8.96 ± 3.38[b]	7.75 ± 3.89[b]	9.35 ± 3.36[cde]	11.19 ± 3.10[abcd]	0.6219
K0T30	8.93 ± 3.50[bc]	7.71 ± 3.76[c]	9.26 ± 3.17[bcd]	11.13 ± 3.09[a]	0.6691
K1T0	8.74 ± 3.62[a]	8.13 ± 3.56[ab]	9.58 ± 3.13[ab]	11.33 ± 3.12[de]	0.4339
K1T15	9.98 ± 3.06[bc]	8.40 ± 3.28[c]	10.16 ± 2.59[def]	10.61 ± 2.82[ab]	0.7086
K1T30	10.08 ± 3.28[bc]	9.10 ± 3.08[c]	10.44 ± 2.32[bcd]	10.36 ± 2.81[ab]	0.7389
K2T0	10.41 ± 3.01[a]	9.39 ± 3.27[ab]	11.04 ± 2.44[ab]	10.55 ± 2.60[cde]	0.3969
K2T15	10.8 ± 2.85[bc]	9.26 ± 3.10[c]	10.11 ± 2.76[f]	10.89 ± 2.65[abcd]	0.9219
K2T30	10.73 ± 3.02[c]	9.10 ± 3.46[c]	9.85 ± 2.99[def]	10.16 ± 2.74[abc]	0.9112
K3T0	10.73 ± 3.42[a]	9.19 ± 3.38[b]	9.93 ± 2.50[bc]	10.34 ± 2.84[e]	0.5249
K3T15	10.91 ± 3.23[bc]	9.48 ± 3.56[c]	10.45 ± 2.82[cde]	10.49 ± 2.68[bcde]	0.9235
K3T30	10.88 ± 3.14[c]	9.49 ± 3.59[c]	10.81 ± 2.74[ef]	10.86 ± 2.60[bcde]	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 complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.[72] 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 doubles 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.[67] 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.[42]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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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 κ-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 κ-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-κ-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.[1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and κ-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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[illegible] based on the modified method of Widyawati et al.[20] and P[illegible]wanto et al.[24] 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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (*L**), redness (*a**), yellowness (*b**), hue (°*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[30]. *C* indicates the color intensity and °*h* states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 µL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ_{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:

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

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.[37] The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 µL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ_{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:

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

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[38] About 250 µL 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 λ_{543} and λ_{700} nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: A = $(A\lambda_{543} - A\lambda_{700})$pH1.0 − $(A\lambda_{543} - A\lambda_{700})$pH4.5. The total anthocyanin monomer content (TA) ($mg \cdot mL^{-1}$) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 $g \cdot mol^{-1}$), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 $L \cdot cm^{-1} \cdot mol^{-1}$).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 µL 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 λ_{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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where A0 = absorbance of the control and As = 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[41]. Approximately 50 µL 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 λ_{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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25−40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^a	0.976 ± 0.01^b	128.36 ± 3.30^a	19.23 ± 0.55^d	0.097 ± 0.097^a
K1	68.20 ± 0.74^a	0.971 ± 0.01^a	133.58 ± 8.42^b	18.93 ± 0.34^c	0.112 ± 0.111^b
K2	68.89 ± 0.73^b	0.970 ± 0.01^a	137.62 ± 6.05^b	18.48 ± 0.23^b	0.141 ± 0.139^c
K3	69.52 ± 0.73^c	0.971 ± 0.01^a	159.11 ± 6.77^c	17.96 ± 0.40^a	0.173 ± 0.171^d

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^a	18.35 ± 0.57^a	0.134 ± 0.034^b
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^a	18.56 ± 0.41^a	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^b	19.04 ± 0.67^b	0.129 ± 0.028^a

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 κ-carrageenan between 1%–3% in the wet noodle formulation reduced the A_w by about 0.005–0.006. The capability of κ-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[48]. 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.

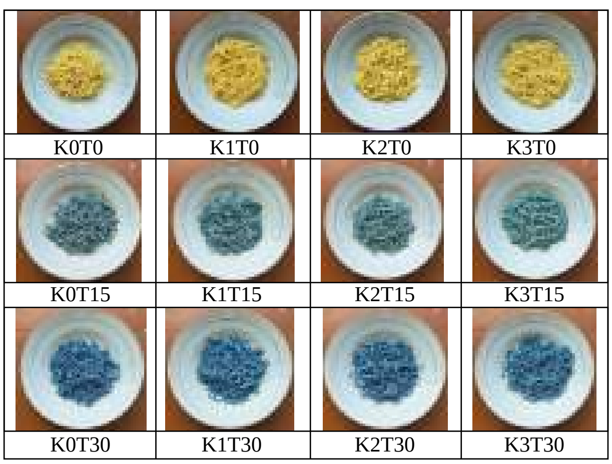

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 ^oh 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 ^oh 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-

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

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

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. κ-carrageenan was synergized with glucomannan to produce a strong stable network that involved sulfhydryl groups. Tako & Konishi[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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[a]	16.74 ± 6.26[a]	0.00 ± 0.00[a]	2.99 ± 0.16[a]	0.009 ± 0.001[a]
K0T15	172.57 ± 2.14[e]	36.66 ± 2.84[d]	2.67 ± 0.21[b]	21.54 ± 1.71[d]	0.023 ± 0.002[c]
K0T30	178.07 ± 2.54[f]	48.36 ± 3.29[f]	3.94 ± 0.28[c]	39.23 ± 0.91[f]	0.027 ± 0.002[e]
K1T0	137.07 ± 1.32[b]	21.66 ± 3.67[b]	0.00 ± 0.00[a]	3.13 ± 0.19[a]	0.011 ± 0.001[a]
K1T15	178.48 ± 0.95[f]	36.95 ± 3.05[d]	2.74 ± 0.21[b]	21.94 ± 0.68[d]	0.023 ± 0.001[cd]
K1T30	183.65 ± 1.67[g]	52.28 ± 3.08[g]	3.84 ± 0.19[c]	41.42 ± 1.30[g]	0.029 ± 0.001[f]
K2T0	150.40 ± 0.52[d]	27.49 ± 5.39[c]	0.00 ± 0.00[a]	7.45 ± 0.69[c]	0.014 ± 0.001[b]
K2T15	202.48 ± 0.63[j]	48.28 ± 2.41[f]	2.95 ± 0.57[b]	24.70 ± 0.90[e]	0.025 ± 0.001[d]
K2T30	206.90 ± 2.43[i]	56.99 ± 7.45[h]	3.93 ± 0.42[c]	47.55 ± 1.31[i]	0.034 ± 0.002[g]
K3T0	141.15 ± 1.28[c]	25.37 ± 3.46[c]	0.00 ± 0.00[a]	5.45 ± 0.49[b]	0.013 ± 0.001[b]
K3T15	186.32 ± 1.15[h]	43.57 ± 2.28[e]	2.66 ± 0.21[b]	22.45 ± 0.48[d]	0.024 ± 0.001[cd]
K3T30	189.90 ± 0.63[k]	54.95 ± 3.72[gh]	3.98 ± 0.37[c]	44.93 ± 1.28[h]	0.031 ± 0.001[f]

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[60], around 2.41 mg/g samples[61] that has more free acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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^{a}	7.41 ± 3.80^{a}	8.71 ± 3.16^{a}	10.78 ± 2.86^{abcde}	0.1597
K0T15	8.96 ± 3.38^{b}	7.75 ± 3.89^{b}	9.35 ± 3.36^{cde}	11.19 ± 3.10^{abcd}	0.6219
K0T30	8.93 ± 3.50^{bc}	7.71 ± 3.76^{c}	9.26 ± 3.17^{bcd}	11.13 ± 3.09^{a}	0.6691
K1T0	8.74 ± 3.62^{a}	8.13 ± 3.56^{ab}	9.58 ± 3.13^{ab}	11.33 ± 3.12^{de}	0.4339
K1T15	9.98 ± 3.06^{bc}	8.40 ± 3.28^{c}	10.16 ± 2.59^{def}	10.61 ± 2.82^{ab}	0.7086
K1T30	10.08 ± 3.28^{bc}	9.10 ± 3.08^{c}	10.44 ± 2.32^{bcd}	10.36 ± 2.81^{ab}	0.7389
K2T0	10.41 ± 3.01^{a}	9.39 ± 3.27^{ab}	11.04 ± 2.44^{ab}	10.55 ± 2.60^{cde}	0.3969
K2T15	10.8 ± 2.85^{bc}	9.26 ± 3.10^{c}	10.11 ± 2.76^{f}	10.89 ± 2.65^{abcd}	0.9219
K2T30	10.73 ± 3.02^{c}	9.10 ± 3.46^{c}	9.85 ± 2.99^{def}	10.16 ± 2.74^{abc}	0.9112
K3T0	10.73 ± 3.42^{a}	9.19 ± 3.38^{b}	9.93 ± 2.50^{bc}	10.34 ± 2.84^{e}	0.5249
K3T15	10.91 ± 3.23^{bc}	9.48 ± 3.56^{c}	10.45 ± 2.82^{cde}	10.49 ± 2.68^{bcde}	0.9235
K3T30	10.88 ± 3.14^{c}	9.49 ± 3.59^{c}	10.81 ± 2.74^{ef}	10.86 ± 2.60^{bcde}	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 complexion of anthocyanins with other molecules also determines their capability as electron or hydrogen donors. Martin et al.[72] 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 doubles 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.[67] 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 ≤ 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.[42]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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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 *κ*-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 *κ*-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-*κ*-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.[1] used wheat-sorghum-guar flour and wheat-millet-guar flour to increase the acceptability of wet noodles. Efendi et al.[2] 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[3] stated that noodles made from wheat flour mixed with up to 7% fenugreek flour produce good texture and high consumer acceptability. Park et al.[4] 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[5,6]. Widyawati et al.[7] explained that using composite flour consisting of wheat flour, stink lily flour, and *κ*-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 effectivity 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.[8] mentioned that incorporating phenolic antioxidants from natural sources can improve the functional values of bread. Widyawati et al.[7] 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[9]. This flower has phytochemical compounds that are antioxidant sources[10,11], including anthocyanins, tannins, phenolics, flavonoids, flobatannins, saponins, triterpenoids, anthraquinones, sterols, alkaloids, and flavonol glycosides[12,13]. Anthocyanins of the butterfly pea flower have been used as natural colorants in many food products[14,15], one of them is wet noodles[16,17]. 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[18]. This interaction involves their formed covalent and non-covalent bonds, which influenced pH and determined hydrophilic-hydrophobic properties and protein digestibility[19]. A previous study has proven that the use of phenolic compounds from plant extracts, such as pluchea leaf[7,20], gendarussa leaf (*Justicia gendarussa*

Burm.F.)[21], carrot and beetroot[22], kelakai leaf[23] contributes to the quality, bioactive compounds, antioxidant activity, and sensory properties of wet noodles. Shiau et al.[17] 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 κ-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.[20] and Putri et al.[24] 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 κ-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.[25], 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 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.

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 : κ-carrageenan = 80:20:0 (%w/w). K1 = wheat flour : stink lily flour : κ-carrageenan = 80:19:1 (%w/w). K2 = wheat flour : stink lily flour : κ-carrageenan = 80:18:2 (%w/w). K3 = wheat flour : stink lily flour : κ-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%.

Extraction of bioactive compounds of wet noodles

Wet noodles were extracted based on the method of Widyawati et al.[7]. 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[26]. 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[27].

Tensile strength analysis

Tensile strength is an essential parameter that measures the extensibility of cooked wet noodles[28]. 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.[29]. The parameters measured were lightness (L^*), redness (a^*), yellowness (b^*), hue (°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[30]. C indicates the color intensity and °h states the color of samples[31].

Swelling index analysis

The swelling index was determined using a modified method of Islamiya[32]. 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[33]. 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.[34]. The cooking loss expresses the weight loss of wet noodles during cooking, indicated by the cooking water that turns cloudy and thick[35]. 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.[36]. About 50 μL 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% Na_2CO_3 was added, and the volume was adjusted to 10 mL with distilled water. The solution's absorbance was measured spectrophotometrically at λ_{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:

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

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.[37]. The procedure began with mixing 0.3 mL of 5% $NaNO_2$ and 250 μL of noodle extract in a 10 mL volumetric flask and incubating the mixture for 5 min. Afterward, 0.3 mL of 10% $AlCl_3$ 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 λ_{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:

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

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[38]. About 250 μL 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 λ_{543} and λ_{700} nm (Spectrophotometer UV-Vis 1800, Shimadzu, Japan). The absorbance (A) of samples was calculated with the formula: $A = (A\lambda_{543} - A\lambda_{700})pH1.0 - (A\lambda_{543} - A\lambda_{700})pH4.5$. The total anthocyanin monomer content (TA) ($mg \cdot mL^{-1}$) was calculated with the formula: $\frac{A \times MW \times DF \times 1000}{\varepsilon \times 1}$, where A was the absorbance of samples, MW was the molecular weight of delphinidin-3-glucoside (449.2 $g \cdot mol^{-1}$), DF was the factor of sample dilution, and ε was the absorptivity molar of delphinidin-3-glucoside (29,000 $L \cdot cm^{-1} \cdot mol^{-1}$).

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

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.[39] and Widyawati et al.[40]. Briefly, 10 μL 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 λ_{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

$$y\ (\%) = \frac{A0 - As}{A0} \times 100\%$$

where, A0 = absorbance of the control and As = 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[41]. Approximately 50 μL 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 λ_{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:

The reducing power (RP) (%) = [(As − A0)/As] × 100%

Where, A0 = absorbance of the control and As = absorbance of the samples.

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

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.[42] 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[43]. 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 determin 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)

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 × 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 κ-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 ± 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 κ-carrageenan. An increase of κ-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[7,20]. Protein networking between gliadin and glutelin forms a three-dimensional networking structure of gluten involving water molecules[44]. 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[45]. κ-carrageenan can bind water molecules around 25−40 times[46]. κ-carrageenan can cause a structure change in gluten protein through electrostatic interactions and hydrogen bonding[47]. The interaction among the major proteins of wheat flour (gliadin and glutelin), glucomannan of stinky lily flour, and κ-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^{a}	0.976 ± 0.01^{b}	128.36 ± 3.30^{a}	19.23 ± 0.55^{d}	0.097 ± 0.097^{a}
K1	68.20 ± 0.74^{a}	0.971 ± 0.01^{a}	133.58 ± 8.42^{b}	18.93 ± 0.34^{c}	0.112 ± 0.111^{b}
K2	68.89 ± 0.73^{b}	0.970 ± 0.01^{a}	137.62 ± 6.05^{b}	18.48 ± 0.23^{b}	0.141 ± 0.139^{c}
K3	69.52 ± 0.73^{c}	0.971 ± 0.01^{a}	159.11 ± 6.77^{c}	17.96 ± 0.40^{a}	0.173 ± 0.171^{d}

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^{a}	18.35 ± 0.57^{a}	0.134 ± 0.034^{b}
T15	68.67 ± 0.66	0.974 ± 0.000	138.77 ± 13.12^{a}	18.56 ± 0.41^{a}	0.130 ± 0.030^{ab}
T30	68.83 ± 1.00	0.970 ± 0.010	144.82 ± 13.55^{b}	19.04 ± 0.67^{b}	0.129 ± 0.028^{a}

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 κ-carrageenan between 1%−3% in the wet noodle formulation reduced the A_w by about 0.005−0.006. The capability of κ-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[48]. 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.

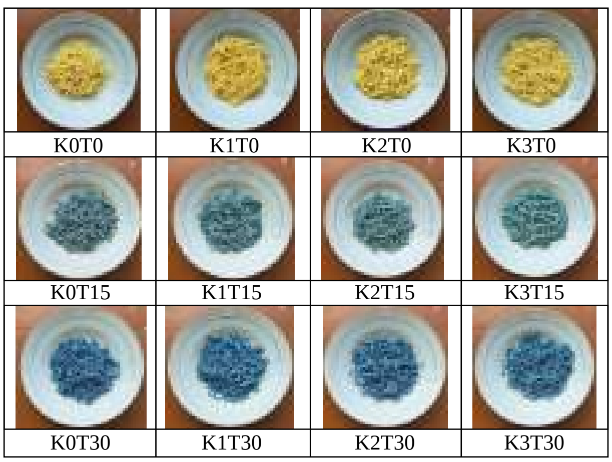

Fig. 1 Color of wet noodles with various proportions of composite flour and concentrations of butterfly pea flower extract.

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 κ-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 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 glutelin, gliadin, glucomannan, κ-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. κ-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 α-(1,3) and β-(1,4) glycosidic linkages[49] that can bind water molecules to form a gel. Glucomannan is a soluble fiber with the β-1,4 linkage main chain of D-glucose and D-mannose that can absorb water molecules around 200 times[50] to form a strong gel that increases the viscosity and swelling index of the dough[51]. Park & Baik[52] stated that the gluten network formation affects the tensile strength of noodles. Huang et al.[48] also reported that κ-carrageenan can increase the firmness and viscosity of samples because of this hydrocolloid's strong water-binding capacity. Cui et al.[45] 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[53]. 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[54]. The cross-linking and polymerization involving functional groups of gluten protein, κ-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[54,55]. The stability of the network dimensional structure of the protein was influenced by the interaction of protein wheat, glucomannan, κ-carrageenan, and polyphenol compounds in the wet noodle dough that determined tensile strength, swelling index, and cooking loss of wet noodles. Schefer et al.[19] & Widyawati et al.[7] 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 π-π stacking. The phenolic compounds of butterfly pea extract interacted with κ-carrageenan, glucomannan, protein, or polysaccharide and influenced complex network structure. The phenolic compounds can disrupt the three-dimensional networking of interaction among gluten protein, κ-carrageenan, and glucomannan through aggregates or chemical breakdown of covalent and noncovalent bonds, and disruption of disulfide bridges to form thiols radicals[55]. 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[19,20,56].

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 ^oh 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 ^oh 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 κ-carrageenan proportion and diminished with increasing butterfly pea flower extract. The chroma and hue of wet noodles decreased with increasing κ-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 κ-carrageenan in composite flour also supported the water-holding capacity of wet noodles that influenced color. κ-carrageenan was

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

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

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[57] reported that κ-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.[58] 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.[59] also found similarities in their research. Anthocyanin pigment of butterfly pea extract can interact with the color of stinky lily and κ-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 κ-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.[20] 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 κ-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 κ-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 ± 0.18 mg delfidine-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 ± 0.90^{a}	16.74 ± 6.26^{a}	0.00 ± 0.00^{a}	2.99 ± 0.16^{a}	0.009 ± 0.001^{a}
K0T15	172.57 ± 2.14^{e}	36.66 ± 2.84^{d}	2.67 ± 0.21^{b}	21.54 ± 1.71^{d}	0.023 ± 0.002^{c}
K0T30	178.07 ± 2.54^{f}	48.36 ± 3.29^{f}	3.94 ± 0.28^{c}	39.23 ± 0.91^{f}	0.027 ± 0.002^{e}
K1T0	137.07 ± 1.32^{b}	21.66 ± 3.67^{b}	0.00 ± 0.00^{a}	3.13 ± 0.19^{a}	0.011 ± 0.001^{a}
K1T15	178.48 ± 0.95^{f}	36.95 ± 3.05^{d}	2.74 ± 0.21^{b}	21.94 ± 0.68^{d}	0.023 ± 0.001^{cd}
K1T30	183.65 ± 1.67^{g}	52.28 ± 3.08^{g}	3.84 ± 0.19^{c}	41.42 ± 1.30^{g}	0.029 ± 0.001^{f}
K2T0	150.40 ± 0.52^{d}	27.49 ± 5.39^{c}	0.00 ± 0.00^{a}	7.45 ± 0.69^{c}	0.014 ± 0.001^{b}
K2T15	202.48 ± 0.63^{j}	48.28 ± 2.41^{f}	2.95 ± 0.57^{b}	24.70 ± 0.90^{e}	0.025 ± 0.001^{d}
K2T30	206.90 ± 2.43^{i}	56.99 ± 7.45^{h}	3.93 ± 0.42^{c}	47.55 ± 1.31^{i}	0.034 ± 0.002^{g}
K3T0	141.15 ± 1.28^{c}	25.37 ± 3.46^{c}	0.00 ± 0.00^{a}	5.45 ± 0.49^{b}	0.013 ± 0.001^{b}
K3T15	186.32 ± 1.15^{h}	43.57 ± 2.28^{e}	2.66 ± 0.21^{b}	22.45 ± 0.48^{d}	0.024 ± 0.001^{cd}
K3T30	189.90 ± 0.63^{k}	54.95 ± 3.72^{gh}	3.98 ± 0.37^{c}	44.93 ± 1.28^{h}	0.031 ± 0.001^{f}

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[60], around 2.41 mg/g samples[61] that has more free acyl groups and aglycone structure[62] 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[63]. Nevertheless, butterfly pea extract is also composed of tannins, phenolics, flavonoids, phlobatannins, saponins, essential oils, triterpenoids, anthraquinones, phytosterols (campesterol, stigmasterol, β-sitosterol, and sitostanol), alkaloids, and flavonol glycosides (kaempferol, quercetin, myricetin, 6-malonylastragalin, phenylalanine, coumaroyl sucrose, tryptophan, and coumaroyl glucose)[12,13], chlorogenic, gallic, p-coumaric caffeic, ferulic, protocatechuic, p-hydroxy benzoic, vanillic, and syringic acids[62], ternatin anthocyanins, fatty acids, tocols, mome inositol, pentanal, cyclohexene, 1-methyl-4(1-methylethylideme), and hirsutene[64], that contribute to the antioxidant activity[10,64]. *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^{2+} reducing power assays[64]. 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.[65] claimed that glucomannan contained in stinky lily has hydroxyl groups that can react with Folin Ciocalteus's phenol reagent. Devaraj et al.[66] reported that 3,5-acetyltalbulin is a flavonoid compound in glucomannan that can form a complex with $AlCl_3$.

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 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.[40] 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 κ-carrageenan proportion and butterfly pea extract for up to 18% and 2% (w/w) of stinky lily flour and κ-carrageenan and 15% (w/w) of extract. However, the use of 17% and 3% (w/w) of stinky lily flour and κ-carrageenan and 30% (w/w) of the extract showed a significant decrease. The results show that the use of stinky lily flour and k-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^{3+} ions to 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 κ-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[67]. Poli et al.[68] stated that bioactive compounds with DPPH free radical scavenging activity are grouped as a primary antioxidant. Nevertheless, Suhendy et al.[69] 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[70]. Previous studies have proven that TPC and TFC significantly contribute to scavenge free radicals[71]. However, TAC showed a weak correlation with TFC, TPC, or AOA, although Choi et al.[71] 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.

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[a]	7.41 ± 3.80[a]	8.71 ± 3.16[a]	10.78 ± 2.86[abcde]	0.1597
K0T15	8.96 ± 3.38[b]	7.75 ± 3.89[b]	9.35 ± 3.36[cde]	11.19 ± 3.10[abcd]	0.6219
K0T30	8.93 ± 3.50[bc]	7.71 ± 3.76[c]	9.26 ± 3.17[bcd]	11.13 ± 3.09[a]	0.6691
K1T0	8.74 ± 3.62[a]	8.13 ± 3.56[ab]	9.58 ± 3.13[ab]	11.33 ± 3.12[de]	0.4339
K1T15	9.98 ± 3.06[bc]	8.40 ± 3.28[c]	10.16 ± 2.59[def]	10.61 ± 2.82[ab]	0.7086
K1T30	10.08 ± 3.28[bc]	9.10 ± 3.08[c]	10.44 ± 2.32[bcd]	10.36 ± 2.81[ab]	0.7389
K2T0	10.41 ± 3.01[a]	9.39 ± 3.27[ab]	11.04 ± 2.44[ab]	10.55 ± 2.60[cde]	0.3969
K2T15	10.8 ± 2.85[bc]	9.26 ± 3.10[c]	10.11 ± 2.76[f]	10.89 ± 2.65[abcd]	0.9219
K2T30	10.73 ± 3.02[c]	9.10 ± 3.46[c]	9.85 ± 2.99[def]	10.16 ± 2.74[abc]	0.9112
K3T0	10.73 ± 3.42[a]	9.19 ± 3.38[b]	9.93 ± 2.50[bc]	10.34 ± 2.84[e]	0.5249
K3T15	10.91 ± 3.23[bc]	9.48 ± 3.56[c]	10.45 ± 2.82[cde]	10.49 ± 2.68[bcde]	0.9235
K3T30	10.88 ± 3.14[c]	9.49 ± 3.59[c]	10.81 ± 2.74[ef]	10.86 ± 2.60[bcde]	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.[72] 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 doubles 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.[67] 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.[42]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.[73] claimed that oxalic acid in stinky lily flour contributes to the odor of rice paper. Therefore, a high proportion of k-carrageenan could reduce the proportion of stink lily flour, thereby increasing the panelists' preference for wet noodle aroma. Sumartini & Putri[74] noted that panelists preferred noodles substituted with a higher κ-carrageenan. Widyawati et al.[7] also proved that κ-carrageenan is an odorless material that does not affect the aroma of wet noodles. Neda et al.[63] 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.[75] 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[76], 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[77]. 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[18,19,77] due to the competition among phenolic compounds, glutelin, gliadin, amylose, glucomannan, κ-carrageenan to interact with water molecules to form gel[78]. 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 κ-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, κ-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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