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38 Rice bran is a by-product of the process of milling grain into rice. The addition of rice bran to making  
39 bread affects the characteristics of the bread because the rice bran does not contain gluten and rich in  
40 fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting bread with  
41 tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in  
42 making rice bran bread can be prevail over by adding hydrocolloid in the form of  
43 Carboxymethylcellulose (CMC). The rice bran added to this research was 10% of the total flour.

44 CMC is a derivative of cellulose and is often used in the food industry, or used in food products to  
45 prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products with the aim  
46 of retaining moisture, improving the mouthfeel of the product, controlling sugar crystallization,  
47 controlling the rheological properties of dough, increasing the development volume (Kohajdová and  
48 Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough  
49 because of its ability to bind free water. The CMC used in this study was Na-CMC.

50 The aim of this research was to study the effect of CMC concentrations of the physicochemical and  
51 sensory properties of bread enriched with rice bran.

52

## 53 **2. Materials and methods**

### 54 *2.1 Materials*

55 The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran,  
56 Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar,  
57 margarine, instant yeast, and bread improver were obtained from local market.

### 58 *2.2 Bread Formulating and Processing*

59 Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar,  
60 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1,  
61 consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with  
62 CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of  
63 control ingredients with CMC at 4 g.

64 The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model)  
65 until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled,  
66 rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C  
67 for 30 mins. The finished bread enriched with rice bran is removed from bread pan and cooled down at  
68 room temperature for 60 minutes.

### 69 *2.3 Experimental Design*

70 The experimental design used was a randomized block design (RBD) with one factor, namely the  
71 concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%;  
72 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times, in  
73 order to obtain 25 experimental units. Data were analysed statistically using ANOVA (Analysis of  
74 Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant  
75 effect on the results of the ANOVA test, then the test was continued with the Duncan's Multiple Range  
76 Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the significant difference results.

## 77 2.4 Evaluation of bread enriched with rice bran characteristic

78 The parameters examined in this study include moisture content, specific volume, and texture profile  
79 including hardness, springiness, cohesiveness and sensory evaluation. Moisture content were measured  
80 with thermo gravimetric method (AOAC 925.10). Specific volume measurements are carried out one  
81 hour after baking with the formula: specific volume ( $\text{cm}^3 / \text{g}$ ) = volume ( $\text{cm}^3$ ) / weight of dough (g). After  
82 being weighed, the sample volume was measured using barley according to Lopez et al. (2004).  
83 Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according  
84 to Gomez et al. (2007). A sensory evaluation which includes ease to bite, softness, and moistness was  
85 conducted by using the hedonic method (Stone and Sidel, 2004). A 7- point scoring was used with 1  
86 representing extremely dislike and 7 representing extremely like. One hundred untrained panelists  
87 participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders.  
88 Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread  
89 samples were labeled with three-digit codes and randomly presented to avoid bias of order of  
90 presentation.

91

## 92 3. Results and discussion

93 The results of the physicochemical properties testing which include moisture content, specific  
94 volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different  
95 concentrations of CMC can be seen in Table 1. The results of sensory properties which include ease to  
96 bite, softness, and moistness of rice bran bread with differences CMC concentrations can be seen in  
97 Table 2.

### 98 3.1 Moisture Content

99 In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When  
100 NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which  
101 increases viscosity (Bochek et al., 2002). According to Fennema (1996), water and hydroxyl groups from  
102 hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a three-  
103 dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement  
104 process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from  
105 NaCMC will undergo an extension and will form an irregular polymer chain, so that water will be trapped  
106 in the polymer chain formed (Allen, 2002). According to research by Sindhu and Bawa (2000), the  
107 addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread  
108 dough. It can be observed in Table 1 that the higher addition of CMC in bread enriched with rice bran  
109 resulting lower moisture content. The higher the water absorption rate in the bread dough, the lower  
110 the moisture content of the bread because the CMC will bind more water.

### 111 3.2 Specific Volume

112 As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume  
113 of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form  
114 cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in  
115 immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to  
116 pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the  
117 concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The  
118 increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap  
119 gas to be better. According the results of research by Sidhu and Bawa (2000), the more CMC is added,

120 the higher gas retention. During baking, there is expansion of CO<sub>2</sub> gas by high temperatures, but  
121 because of the high gas retention, the shape of the bread can be maintained and the volume of bread is  
122 higher.

### 123 3.3 Hardness

124 Table 1. shows that the hardness value decreases with the increase addition of CMC. The  
125 addition of CMC resulted in decreased hardness of bread because the hydrocolloid was able to provide  
126 elastic properties so that the force required for crumb deformation was smaller. Hardness value is  
127 influenced by crumb porosity and is related to a specific volume. According to Sciarini et al. (2012), the  
128 addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo et al.  
129 (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made  
130 from high protein flour will have a strong and less elastic structure, due to the very strong  
131 intermolecular interactions. After baking the bread will have a firm texture and dense pores. The  
132 addition of CMC can increase the viscoelasticity of bread dough so that the texture of bread becomes  
133 easier to deform.

### 134 3.4 Springiness

135 The springiness value of the product has a positive correlation with elasticity. According to  
136 Mohammadi et al. (2014), the higher addition of CMC will resulted more elastic bread. According to  
137 Grubber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase  
138 was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in  
139 polymer concentration makes the polymer chains increasingly difficult to separate from one another.

140 The addition of CMC can affect springiness because the addition of hydrocolloid can increase the  
141 elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen  
142 bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher  
143 the elastic pore walls of rice bran bread, the higher the springiness value. The results of the springiness  
144 test of bread enriched with rice bran can be observed in Table 1.

### 145 3.5 Cohesiveness

146 Table 1 shows that the cohesiveness value increases with the increase addition of CMC.  
147 According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the  
148 tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact  
149 so that the bread is not easily crushed during the processing. According to Lazaridou et al. (2007), the  
150 addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network  
151 that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact  
152 with other components besides water such as protein because CMC has carboxyl groups that can join  
153 the positive charge groups of proteins. The bonds between CMC and other components can strengthen  
154 the structure of the bread.

### 155 3.6 Ease to bite

156 The preference for ease to bite has correlation with hardness. The hardness value describes the  
157 structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the  
158 bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease  
159 to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread  
160 enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread  
161 structure is influenced by the shape of the structure of the bread itself. In general, what affects the



162 structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the  
163 structure of the bread produced by bonding with the components in the dough such as water. The bond  
164 between CMC and water creates an easy-to-bite texture of bread. The CMC concentration of 2%  
165 resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred. The  
166 results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2.

### 167 *3.7 Softness*

168 The results of bread enriched with rice bran softness can be observed in Table 2. The addition of  
169 CMC affects on the softness of bread. This is due to the addition of CMC to produce bread with smaller  
170 pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin  
171 and soft pore walls. The higher CMC concentration, it will produce bread with thinner and larger pore  
172 walls so that the resulting bread structure becomes softer. The value of the softness of bread enriched  
173 with rice bran that is preferred by the panellists is at a CMC concentration of 1.5-2% with an average  
174 sensory test value of 5.20-5.24 (slightly preferred).

### 175 *3.8 Moistness*

176 The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC  
177 concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC  
178 resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain  
179 moisture and improve mouthfeel of bakery products. Moistness of bread has correlation with moisture  
180 content. CMC has water binding properties. The higher CMC concentrations, hence the water bound in  
181 the bread tissue increases, thereby increasing the impression of moistness when bread is consumed.  
182 The results sensory test value (moistness) of bread enriched with rice bran bread can be observed in  
183 Table 2.

184

## 185 **4. Conclusion**

186 The increase in CMC concentration causes a decrease in moisture content, an increase in specific  
187 volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread  
188 enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to  
189 an increase preference in ease to bite, softness and moistness.

190

### 191 **Conflict of interest**

192 The authors declare no conflict of interest.

193

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272 **Tables and Figures**

273 Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of  
274 CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27 <sup>c</sup>	3.29 <sup>b</sup>	724.86 <sup>e</sup>	0.92 <sup>a</sup>	0.64 <sup>a</sup>
0,5	42.26 <sup>c</sup>	2.96 <sup>a</sup>	683.64 <sup>d</sup>	0.92 <sup>ab</sup>	0.65 <sup>b</sup>
1	42.18 <sup>bc</sup>	3.40 <sup>c</sup>	557.14 <sup>c</sup>	0.93 <sup>ab</sup>	0.66 <sup>bc</sup>
1,5	42.05 <sup>b</sup>	3.55 <sup>d</sup>	451.13 <sup>b</sup>	0.93 <sup>bc</sup>	0.66 <sup>bc</sup>
2	41.79 <sup>a</sup>	3.61 <sup>e</sup>	326.93 <sup>a</sup>	0.95 <sup>c</sup>	0.67 <sup>c</sup>

275 \*Values are means ± standard deviations (n=3 for each group). Values in a column with the same letters  
276 are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA followed by  
277 DMRT test (α = 0.05).

278

279 Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79 <sup>ab</sup>	3.76 <sup>a</sup>	3.83 <sup>a</sup>
0.5	4.55 <sup>a</sup>	4.41 <sup>b</sup>	4.34 <sup>b</sup>
1	5.00 <sup>b</sup>	4.45 <sup>b</sup>	4.45 <sup>b</sup>
1.5	5.03 <sup>b</sup>	5.20 <sup>c</sup>	5.00 <sup>c</sup>
2	5.52 <sup>c</sup>	5.24 <sup>c</sup>	5.02 <sup>c</sup>

280 \*Values are means ± standard deviations (n=100 for each group). Values in a column with the same  
281 letters are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA  
282 followed by DMRT test (α = 0.05).

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286 Figure 1. Cross section of of bread enriched with rice bran with different addition of CMC

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1 **Effect of Carboxymethylcellulose on the Physicochemical and Sensory Properties of**  
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3 Harsono, C., \*Trisnawati, C.Y., Srianta, I., Nugerahani, I. and Marsono, Y.

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8 **Abstract**

9 Bread enriched with rice bran is one of the innovation product of bread. Addition of rice bran aims to  
10 increase the fibre content in bread so it can be developed as functional bread. Addition of 10% rice bran  
11 into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice  
12 bran to be harder. Texture and volume development problems in the making of bread enriched with rice  
13 bran can be improved by adding Carboxymethylcellulose (CMC). The aim of the research was to observe  
14 the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with  
15 rice bran. The research design was Randomized Block Design consisting of one factor which was the  
16 CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results  
17 showed that increasing CMC concentration decreased moisture content in bread enriched with rice  
18 bran; increased specific volume; decreased hardness; increased springiness; increased cohesiveness;  
19 increased preference sensory properties ease to bite; softness; and moistness. The best treatment  
20 determined based on sensory test results with the spiderweb method was 2% CMC addition. Bread  
21 enriched with rice bran with 2% CMC concentration has moisture content 41.79%; specific volume 3.61  
22 cm<sup>3</sup>/g; hardness 326.93 g; springiness 0.95 mm; cohesiveness 0,67; preference for ease of bite 5.52  
23 (slightly preferred); preference for softness 5.24 (slightly preferred); and preference for moistness 5.02  
24 (slightly preferred).

25 **Keywords:** bread enriched with rice bran, carboxymethylcellulose, physicochemical properties, sensory  
26 properties

27  
28 **1. Introduction**

29 Bread is one of the oldest and most popular source of processed food products. Bread made from  
30 flour, water, yeast and other ingredients. The basic bread making process includes kneading,  
31 fermentation and baking. The high level of bread consumption and the increasing need for healthier  
32 food products have encouraged innovations in bakery products.

33 Ameh, Gernah, and Igbabul (2013) reported the results of the analysis of the crude fibre content of  
34 white bread substituted with rice bran as much as 10%, which was significantly different from control  
35 bread and bread substituted with 5% rice bran but there was no significant difference with substitute of  
36 15% rice bran. Trisnawati et al. (2019) reported that the addition of 10% rice bran to the plain bread  
37 formula had a significant effect on sensory properties but was still acceptable to the panellists.

38 Rice bran is a by-product of the process of milling grain into rice. The addition of rice bran to making  
39 bread affects the characteristics of the bread because the rice bran does not contain gluten and rich in  
40 fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting bread with  
41 tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in  
42 making rice bran bread can be prevail over by adding hydrocolloid in the form of  
43 Carboxymethylcellulose (CMC). The rice bran added to this research was 10% of the total flour.

44 CMC is a derivative of cellulose and is often used in the food industry, or used in food products to  
45 prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products with the aim  
46 of retaining moisture, improving the mouthfeel of the product, controlling sugar crystallization,  
47 controlling the rheological properties of dough, increasing the development volume (Kohajdová and  
48 Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough  
49 because of its ability to bind free water. The CMC used in this study was Na-CMC.

50 The aim of this research was to study the effect of CMC concentrations of the physicochemical and  
51 sensory properties of bread enriched with rice bran.

52

## 53 **2. Materials and methods**

### 54 *2.1 Materials*

55 The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran,  
56 Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar,  
57 margarine, instant yeast, and bread improver were obtained from local market.

### 58 *2.2 Bread Formulating and Processing*

59 Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar,  
60 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1,  
61 consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with  
62 CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of  
63 control ingredients with CMC at 4 g.

64 The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model)  
65 until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled,  
66 rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C  
67 for 30 mins. The finished bread enriched with rice bran is removed from bread pan and cooled down at  
68 room temperature for 60 minutes.

### 69 *2.3 Experimental Design*

70 The experimental design used was a randomized block design (RBD) with one factor, namely the  
71 concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%;  
72 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times, in  
73 order to obtain 25 experimental units. Data were analysed statistically using ANOVA (Analysis of  
74 Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant  
75 effect on the results of the ANOVA test, then the test was continued with the Duncan's Multiple Range  
76 Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the significant difference results.



## 77 2.4 Evaluation of bread enriched with rice bran characteristic

78 The parameters examined in this study include moisture content, specific volume, and texture profile  
79 including hardness, springiness, cohesiveness and sensory evaluation. Moisture content were measured  
80 with thermo gravimetric method (AOAC 925.10). Specific volume measurements are carried out one  
81 hour after baking with the formula: specific volume ( $\text{cm}^3 / \text{g}$ ) = volume ( $\text{cm}^3$ ) / weight of dough (g). After  
82 being weighed, the sample volume was measured using barley according to Lopez et al. (2004).  
83 Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according  
84 to Gomez et al. (2007). A sensory evaluation which includes ease to bite, softness, and moistness was  
85 conducted by using the hedonic method (Stone and Sidel, 2004). A 7- point scoring was used with 1  
86 representing extremely dislike and 7 representing extremely like. One hundred untrained panelists  
87 participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders.  
88 Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread  
89 samples were labeled with three-digit codes and randomly presented to avoid bias of order of  
90 presentation.

91

## 92 3. Results and discussion

93 The results of the physicochemical properties testing which include moisture content, specific  
94 volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different  
95 concentrations of CMC can be seen in Table 1. The results of sensory properties which include ease to  
96 bite, softness, and moistness of rice bran bread with differences CMC concentrations can be seen in  
97 Table 2.

### 98 3.1 Moisture Content

99 In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When  
100 NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which  
101 increases viscosity (Bochek et al., 2002). According to Fennema (1996), water and hydroxyl groups from  
102 hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a three-  
103 dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement  
104 process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from  
105 NaCMC will undergo an extension and will form an irregular polymer chain, so that water will be trapped  
106 in the polymer chain formed (Allen, 2002). According to research by Sindhu and Bawa (2000), the  
107 addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread  
108 dough. **It can be observed in Table 1 that the higher addition of CMC in bread enriched with rice bran**  
109 **resulting lower moisture content.** The higher the water absorption rate in the bread dough, the lower  
110 the moisture content of the bread because the CMC will bind more water.

### 111 3.2 Specific Volume

112 As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume  
113 of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form  
114 cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in  
115 immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to  
116 pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the  
117 concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The  
118 increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap  
119 gas to be better. According the results of research by Sidhu and Bawa (2000), the more CMC is added,

120 the higher gas retention. During baking, there is expansion of CO<sub>2</sub> gas by high temperatures, but  
121 because of the high gas retention, the shape of the bread can be maintained and the volume of bread is  
122 higher.

### 123 3.3 Hardness

124 Table 1. shows that the hardness value decreases with the increase addition of CMC. The  
125 addition of CMC resulted in decreased hardness of bread because the hydrocolloid was able to provide  
126 elastic properties so that the force required for crumb deformation was smaller. Hardness value is  
127 influenced by crumb porosity and is related to a specific volume. According to Sciarini et al. (2012), the  
128 addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo et al.  
129 (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made  
130 from high protein flour will have a strong and less elastic structure, due to the very strong  
131 intermolecular interactions. **After baking the bread will have a firm texture and dense pores. The  
132 addition of CMC can increase the viscoelasticity of bread dough so that the texture of bread becomes  
133 easier to deform.**

### 134 3.4 Springiness

135 The springiness value of the product has a positive correlation with elasticity. **According to  
136 Mohammadi et al. (2014), the higher addition of CMC will resulted more elastic bread.** According to  
137 Grubber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase  
138 was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in  
139 polymer concentration makes the polymer chains increasingly difficult to separate from one another.

140 The addition of CMC can affect springiness because the addition of hydrocolloid can increase the  
141 elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen  
142 bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher  
143 the elastic pore walls of rice bran bread, the higher the springiness value. The results of the springiness  
144 test of bread enriched with rice bran can be observed in Table 1. **Need to interpret further the results  
145 here with discussion???**

### 146 3.5 Cohesiveness

147 Table 1 shows that the cohesiveness value increases with the increase addition of CMC.  
148 According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the  
149 tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact  
150 so that the bread is not easily crushed during the processing. According to Lazaridou et al. (2007), the  
151 addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network  
152 that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact  
153 with other components besides water such as protein because CMC has carboxyl groups that can join  
154 the positive charge groups of proteins. The bonds between CMC and other components can strengthen  
155 the structure of the bread.

### 156 3.6 Ease to bite

157 The preference for ease to bite has correlation with hardness. The hardness value describes the  
158 structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the  
159 bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease  
160 to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread  
161 enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread

162 structure is influenced by the shape of the structure of the bread itself. In general, what affects the  
163 structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the  
164 structure of the bread produced by bonding with the components in the dough such as water. The bond  
165 between CMC and water creates an easy-to-bite texture of bread. The CMC concentration of 2%  
166 resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred. **The**  
167 **results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2. ( This sentence**  
168 **is hanging as not clear whats next???)**

### 169 3.7 Softness

170 The results of bread enriched with rice bran softness can be observed in Table 2. The addition of  
171 CMC affects on the softness of bread. This is due to the addition of CMC to produce bread with smaller  
172 pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin  
173 and soft pore walls. The higher CMC concentration, it will produce bread with thinner and larger pore  
174 walls so that the resulting bread structure becomes softer. **The value of the softness of bread enriched**  
175 **with rice bran that is preferred by the panellists is at a CMC concentration of 1.5-2% with an average**  
176 **sensory test value of 5.20-5.24 (slightly preferred). (again results statement after discussion?)**

### 177 3.8 Moistness

178 The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC  
179 concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC  
180 resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain  
181 moisture and improve mouthfeel of bakery products. Moistness of bread has correlation with moisture  
182 content. CMC has water binding properties. The higher CMC concentrations, hence the water bound in  
183 the bread tissue increases, thereby increasing the impression of moistness when bread is consumed.  
184 **The results sensory test value (moistness) of bread enriched with rice bran bread can be observed in**  
185 **Table 2. (again results statement after discussion?)**

186

## 187 4. Conclusion

188 The increase in CMC concentration causes a decrease in moisture content, an increase in specific  
189 volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread  
190 enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to  
191 an increase preference in ease to bite, softness and moistness.

192

### 193 Conflict of interest

194 The authors declare no conflict of interest.

195

### 196 Acknowledgments

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274 **Tables and Figures**

275 Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of  
276 CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27 <sup>c</sup>	3.29 <sup>b</sup>	724.86 <sup>e</sup>	0.92 <sup>a</sup>	0.64 <sup>a</sup>
0,5	42.26 <sup>c</sup>	2.96 <sup>a</sup>	683.64 <sup>d</sup>	0.92 <sup>ab</sup>	0.65 <sup>b</sup>
1	42.18 <sup>bc</sup>	3.40 <sup>c</sup>	557.14 <sup>c</sup>	0.93 <sup>ab</sup>	0.66 <sup>bc</sup>
1,5	42.05 <sup>b</sup>	3.55 <sup>d</sup>	451.13 <sup>b</sup>	0.93 <sup>bc</sup>	0.66 <sup>bc</sup>
2	41.79 <sup>a</sup>	3.61 <sup>e</sup>	326.93 <sup>a</sup>	0.95 <sup>c</sup>	0.67 <sup>c</sup>

277 \*Values are means ± standard deviations (n=3 for each group). Values in a column with the same letters  
278 are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA followed by  
279 DMRT test (α = 0.05).

280

281 Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79 <sup>ab</sup>	3.76 <sup>a</sup>	3.83 <sup>a</sup>
0.5	4.55 <sup>a</sup>	4.41 <sup>b</sup>	4.34 <sup>b</sup>
1	5.00 <sup>b</sup>	4.45 <sup>b</sup>	4.45 <sup>b</sup>
1.5	5.03 <sup>b</sup>	5.20 <sup>c</sup>	5.00 <sup>c</sup>
2	5.52 <sup>c</sup>	5.24 <sup>c</sup>	5.02 <sup>c</sup>

282 \*Values are means ± standard deviations (n=100 for each group). Values in a column with the same  
283 letters are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA  
284 followed by DMRT test (α = 0.05).

285

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287

288 Figure 1. Cross section of of bread enriched with rice bran with different addition of CMC

289

3.

Bukti konfirmasi review dan hasil review dari Reviewer II

(22 Januari 2021)

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Dear Chatarina Yayuk Trisnawati,

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Best regards,  
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1 **Effect of Carboxymethylcellulose on the Physicochemical and Sensory Properties of**  
2 **Bread Enriched with Rice Bran**

3 **Abstract**

4 Bread enriched with rice bran is one of the ~~innovation-product~~ **innovative products** of bread. Addition of  
5 ~~rice bran aims to increase the fibre content in bread so it can be developed as functional bread.~~ **The**  
6 **A**ddition of 10% rice bran into bread will reduce the specific volume of bread and result in the texture  
7 of bread enriched with rice bran ~~to be being~~ harder. Texture and volume development problems in the  
8 making of bread enriched with rice bran can be improved by adding Carboxymethylcellulose (CMC). **The**  
9 ~~aim of the research was~~ **the reseach aimed** to observe the effect of CMC concentration on the  
10 physicochemical and sensory properties of bread enriched with rice bran. The research design was **a**  
11 Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%,  
12 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration  
13 decreased moisture content in bread enriched with rice bran; increased specific volume; decreased  
14 hardness; increased springiness; increased cohesiveness; increased preference sensory properties ease  
15 to bite; softness; and moistness. The best treatment determined based on sensory test results with the  
16 spiderweb method was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has  
17 moisture content 41.79%; specific volume 3.61 cm<sup>3</sup>/g; hardness 326.93 g; springiness 0.95 mm;  
18 cohesiveness 0,67; preference for ease of bite 5.52 (slightly preferred); preference for softness 5.24  
19 (slightly preferred); and preference for moistness 5.02 (slightly preferred).

20 **Keywords:** bread enriched with rice bran, carboxymethylcellulose, physicochemical properties, sensory  
21 properties

22  
23 **1. Introduction**

24 Bread is one of the oldest and most popular source~~s~~ of processed food products. Bread **is** made  
25 from flour, water, yeast, and other ingredients. The basic bread-making process includes kneading,  
26 fermentation and baking. The high level of bread consumption and the increasing need for healthier  
27 food products have encouraged innovations in bakery products.

28 Ameh, Gernah, and Igbabul (2013) reported the results of the analysis of the crude ~~fibre~~ **fiber**  
29 content of white bread substituted with rice bran as much as 10%, which was significantly different from  
30 control bread and bread substituted with 5% rice bran but there was no significant difference with **the**  
31 substitute of 15% rice bran. Trisnawati et al. (2019) reported that the addition of 10% rice bran to the  
32 plain bread formula had a significant effect on sensory properties but was still acceptable to the  
33 panelists.

34 Rice bran is a by-product of the process of milling grain into **the** rice. The addition of rice bran to  
35 making bread affects the characteristics of the bread because the rice bran does not contain gluten and  
36 rich in ~~fibre~~ **fiber**. The reduction of gluten and increased ~~fibre~~ **fiber** in the manufacture of bread resulting  
37 bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion  
38 volume in making rice bran bread can ~~be~~ prevail over by adding hydrocolloid in the form of  
39 Carboxymethylcellulose (CMC). The rice bran added to this research was 10% of the total flour.

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40 CMC is a derivative of cellulose and is often used in the food industry, or used in food products to  
41 prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products ~~with the aim~~  
42 ~~of retaining to retain~~ moisture, improving the mouthfeel of the product, controlling sugar crystallization,  
43 controlling the rheological properties of dough, increasing the development volume (Kohajdová and  
44 Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough  
45 because of its ability to bind free water. The CMC used in this study was Na-CMC.

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46 ~~The aim of this research aimed was~~ to study the effect of CMC concentrations ~~of on~~ the  
47 physicochemical and sensory properties of bread enriched with rice bran.

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## 49 2. Materials and methods

### 50 2.1 Materials

51 The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran,  
52 Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar,  
53 margarine, instant yeast, and bread improver were obtained from the local market.

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### 54 2.2 Bread Formulating and Processing

55 Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar,  
56 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast, and 124 g of water; 2) C1,  
57 consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with  
58 CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of  
59 control ingredients with CMC at 4 g.

60 The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model)  
61 until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled,  
62 rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C  
63 for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down  
64 at room temperature for 60 minutes.

### 65 2.3 Experimental Design

66 The experimental design used was a randomized block design (RBD) with one factor, namely the  
67 concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%;  
68 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated ~~five times, in~~  
69 ~~order to obtain 25 experimental units~~. Data were analyzed statistically using ANOVA (Analysis of  
70 Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant  
71 effect on the results of the ANOVA test, then the test was continued with the Duncan's Multiple Range  
72 Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the significantly ~~difference~~ different  
73 results.

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### 74 2.4 Evaluation of bread enriched with rice bran characteristic

75 The parameters examined in this study include moisture content, specific volume, and texture profile  
76 including hardness, springiness, cohesiveness and sensory evaluation. Moisture content ~~were was~~  
77 measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements are  
78 carried out one hour after baking with the formula: specific volume ( $\text{cm}^3 / \text{g}$ ) = volume ( $\text{cm}^3$ ) / weight of  
79 dough (g). After being weighed, the sample volume was measured using barley according to Lopez et al.

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80 (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus  
81 according to Gomez et al. (2007). A sensory evaluation which includes ease to bite, softness, and  
82 moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7- point scoring was  
83 used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained  
84 panelists participated in the sensory evaluation. Panelists had no previous or present taste or smell  
85 disorders. Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1  
86 cm, bread samples were labeled with three-digit codes and randomly presented to avoid the bias of  
87 order of presentation.

88

### 89 3. Results and discussion

90 The results of the physicochemical properties testing which include moisture content, specific  
91 volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different  
92 concentrations of CMC can be seen in Table 1. The results of sensory properties which include ease to  
93 bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in  
94 Table 2.

#### 95 3.1 Moisture Content

96 In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When  
97 NaCMC is dispersed in water, Na<sup>+</sup> will be released and replaced with H<sup>+</sup> ions and form HCMC which  
98 increases the viscosity (Bochek et al., 2002). According to Fennema (1996), water and hydroxyl groups  
99 from hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a  
100 three-dimensional structure. The mechanism for the formation of NaCMC gel is through the  
101 entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer  
102 chain from NaCMC will undergo an extension and will form an irregular polymer chain, so that water will  
103 be trapped in the polymer chain formed (Allen, 2002). According to research by Sindhu and Bawa  
104 (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate  
105 of bread dough. It can be observed in Table 1 that the higher addition of CMC in bread enriched with  
106 rice bran resulting lower moisture content. The higher the water absorption rate in the bread dough, the  
107 lower the moisture content of the bread because the CMC will bind more water.

#### 108 3.2 Specific Volume

109 As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume  
110 of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form  
111 cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in  
112 immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to  
113 pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the  
114 concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The  
115 increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap  
116 gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added,  
117 the higher gas retention. During baking, there is an expansion of CO<sub>2</sub> gas by at high temperatures, but  
118 because of the high gas retention, the shape of the bread can be maintained and the volume of bread is  
119 higher.

#### 120 3.3 Hardness

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121 Table 1. shows that the hardness value decreases with the increased addition of CMC. The  
122 addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to  
123 provide elastic properties so that the force required for crumb deformation was smaller. The Hardness  
124 value is influenced by crumb porosity and is related to a specific volume. According to Sciarini et al.  
125 (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to  
126 Tronsmo et al. (2003), the porosity of bread is determined by the rheological properties of the dough.  
127 Dough made from high protein flour will have a strong and less elastic structure, due to the very strong  
128 intermolecular interactions. After baking the bread will have a firm texture and dense pores. The  
129 addition of CMC can increase the viscoelasticity of bread dough so that the texture of bread becomes  
130 easier to deform.

#### 131 3.4 Springiness

132 The springiness value of the product has a positive correlation with elasticity. According to  
133 Mohammadi et al. (2014), the higher addition of CMC will result ed in more elastic bread. According to  
134 Grubber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase  
135 was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in  
136 polymer concentration makes the polymer chains increasingly difficult to separate from one another.

137 The addition of CMC can affect springiness because the addition of hydrocolloid can increase the  
138 elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen  
139 bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher  
140 the elastic pore walls of rice bran bread, the higher the springiness value. The results of the springiness  
141 test of bread enriched with rice bran can be observed in Table 1.

#### 142 3.5 Cohesiveness

143 Table 1 shows that the cohesiveness value increases with the increased addition of CMC.  
144 According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the  
145 tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact  
146 so that the bread is not easily crushed during the processing. According to Lazaridou et al. (2007), the  
147 addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network  
148 that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact  
149 with other components besides water such as protein because CMC has carboxyl groups that can join  
150 the positive charge groups of proteins. The bonds between CMC and other components can strengthen  
151 the structure of the bread.

#### 152 3.6 Ease to bite

153 The preference for ease to bite has a correlation with hardness. The hardness value describes the  
154 structural strength of the bread enriched with rice bran. The higher- the hardness value, the stronger the  
155 bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease  
156 to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread  
157 enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread  
158 structure is influenced by the shape of the structure of the bread itself. In general, what affects the  
159 structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the  
160 structure of the bread produced by bonding with the components in the dough such as water. The bond  
161 between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2%  
162 resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred. The  
163 results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2.

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164 3.7 Softness

165 The results of bread enriched with rice bran softness can be observed in Table 2. The addition of  
166 CMC affects ~~on~~ the softness of bread. This is due to the addition of CMC to produce bread with smaller  
167 pore sizes and thin pore walls (Sciarini, 2012). ~~Panelists~~ prefer white bread with its characteristic thin  
168 and soft pore walls. The higher CMC concentration, ~~it will produce bread with thinner and larger pore~~  
169 walls so that the resulting bread structure becomes softer. The value of the softness of bread enriched  
170 with rice bran that is preferred by the ~~panelists~~ panelists is at a CMC concentration of 1.5-2% with an  
171 average sensory test value of 5.20-5.24 (slightly preferred).

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172 3.8 Moistness

173 The ~~panelists~~ panelists preferred bread enriched with rice bran of moistness at 1.5-2% CMC  
174 concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC  
175 resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain  
176 moisture and improve the mouthfeel of bakery products. The Moistness of bread has a correlation with  
177 moisture content. CMC has water-~~binding~~ properties. The higher CMC concentrations, hence the water  
178 bound in the bread tissue increases, thereby increasing the impression of moistness when the bread is  
179 consumed. The results sensory test value (moistness) of bread enriched with rice bran bread can be  
180 observed in Table 2.

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182 4. Conclusion

183 The increase in CMC concentration causes a decrease in moisture content, an increase in specific  
184 volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread  
185 enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to  
186 an increase preference in ease to bite, softness and moistness.

187

188 Conflict of interest

189 The authors declare no conflict of interest.

190

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274 **Tables and Figures**

275 Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of  
276 CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27 <sup>c</sup>	3.29 <sup>b</sup>	724.86 <sup>e</sup>	0.92 <sup>a</sup>	0.64 <sup>a</sup>
0,5	42.26 <sup>c</sup>	2.96 <sup>a</sup>	683.64 <sup>d</sup>	0.92 <sup>ab</sup>	0.65 <sup>b</sup>
1	42.18 <sup>bc</sup>	3.40 <sup>c</sup>	557.14 <sup>c</sup>	0.93 <sup>ab</sup>	0.66 <sup>bc</sup>
1,5	42.05 <sup>b</sup>	3.55 <sup>d</sup>	451.13 <sup>b</sup>	0.93 <sup>bc</sup>	0.66 <sup>bc</sup>
2	41.79 <sup>a</sup>	3.61 <sup>e</sup>	326.93 <sup>a</sup>	0.95 <sup>c</sup>	0.67 <sup>c</sup>

277 \*Values are means ± standard deviations (n=3 for each group). Values in a column with the same letters  
278 are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA followed by  
279 DMRT test (α = 0.05).

280

281 Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79 <sup>ab</sup>	3.76 <sup>a</sup>	3.83 <sup>a</sup>
0.5	4.55 <sup>a</sup>	4.41 <sup>b</sup>	4.34 <sup>b</sup>
1	5.00 <sup>b</sup>	4.45 <sup>b</sup>	4.45 <sup>b</sup>
1.5	5.03 <sup>b</sup>	5.20 <sup>c</sup>	5.00 <sup>c</sup>
2	5.52 <sup>c</sup>	5.24 <sup>c</sup>	5.02 <sup>c</sup>

282 \*Values are means ± standard deviations (n=100 for each group). Values in a column with the same  
283 letters are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA  
284 followed by DMRT test (α = 0.05).

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288 Figure 1. Cross section of of bread enriched with rice bran with different addition of CMC

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4.

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Chatarina Yayuk Trisnawati, STP., MP, <chatarina@ukwms.ac.id> to Food

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Dear Prof. Dr. Son Radu.

Please kindly find the attached files of my revised manuscript entitle "Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran" and response to reviewer comments. I'm waiting for your feedback. Thank you.

Best regards,  
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37 reported the results of the analysis of the crude fiber content of white bread substituted with rice bran  
38 as much as 10%, which was significantly different from control bread and bread substituted with 5% rice  
39 bran but there was no significant difference with the substitute of 15% rice bran. Trisnawati *et al.* (2019)  
40 reported that the addition of 10% rice bran to the plain bread formula had a significant effect on sensory  
41 properties but was still acceptable to the panelists.

42 The addition of rice bran to making bread affects the characteristics of the bread because the rice  
43 bran does not contain gluten and rich in fiber. The reduction of gluten and increased fiber in the  
44 manufacture of bread resulting bread with tougher texture and reduced expansion volume. The tougher  
45 texture and reduced expansion volume in making rice bran bread can prevail over by adding  
46 hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of  
47 CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was  
48 10% of the total flour.

49 CMC is a derivative of cellulose and is often used in the food industry, or used in food products to  
50 prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain  
51 moisture, improving the mouthfeel of the product, controlling sugar crystallization, controlling the  
52 rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009).  
53 CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability  
54 to bind free water. The CMC used in this study was Na-CMC.

55 This research aimed to study the effect of CMC concentrations on the physicochemical and sensory  
56 properties of bread enriched with rice bran.

57

## 58 **2. Materials and methods**

### 59 *2.1 Materials*

60 The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran,  
61 Na-CMC (Natrium Carboxymethylcelullose), full cream milk powder, mineral water, iodized salt, sugar,  
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### 63 *2.2 Bread formulation and processing*

64 Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar,  
65 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1,  
66 consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with  
67 CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of  
68 control ingredients with CMC at 4 g.

69 The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model)  
70 until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled,  
71 rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C  
72 for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down  
73 at room temperature for 60 minutes.

### 74 *2.3 Experimental design*

75 The experimental design used was a randomized block design (RBD) with one factor, namely the  
76 concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%;  
77 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data  
78 were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the  
79 treatment had a significant effect. If there is a significant effect on the results of the ANOVA, it was  
80 followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the  
81 significantly different results.

## 82 *2.4 Evaluation of bread enriched with rice bran characteristics*

83 The parameters examined in this study include moisture content, specific volume, and texture profile  
84 including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured  
85 with the thermogravimetric method (AOAC 925.10). Specific volume measurements are carried out one  
86 hour after baking with the formula: specific volume ( $\text{cm}^3 / \text{g}$ ) = volume ( $\text{cm}^3$ ) / weight of bread (g). After  
87 being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004).  
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89 to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was  
90 conducted by using the hedonic method (Stone and Sidel, 2004). A 7- point scoring was used with 1  
91 representing extremely dislike and 7 representing extremely like. One hundred untrained panelists  
92 participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders.  
93 Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread  
94 samples were labeled with three-digit codes and randomly presented to avoid the bias of order of  
95 presentation.

96

## 97 **3. Results and discussion**

98 The results of the physicochemical properties testing which include moisture content, specific  
99 volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different  
100 concentrations of CMC can be seen in Table 1. The results of sensory properties which include  
101 preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC  
102 concentrations can be seen in Table 2.

### 103 *3.1 Moisture content*

104 Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the  
105 water absorption rate in the bread dough, the lower the moisture content of the bread because the  
106 CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of  
107 NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form  
108 HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and  
109 hydroxyl groups from hydrocolloids will bond through hydrogen bonds and form a double helix  
110 conformation to form a three-dimensional structure. The mechanism for the formation of NaCMC gel is  
111 through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water,  
112 the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain, so  
113 that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu  
114 and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water  
115 absorption rate of bread dough.

### 116 *3.2 Specific volume*

117 As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume  
118 of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form  
119 cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in  
120 immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to  
121 pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the  
122 concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The  
123 increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap  
124 gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added,  
125 the higher gas retention. During baking, there is an expansion of CO<sub>2</sub> gas at high temperatures, but  
126 because of the high gas retention, the shape of the bread can be maintained and the volume of bread is  
127 higher.

### 128 3.3 Hardness

129 Table 1. shows that the hardness value decreases with the increased addition of CMC. The  
130 addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to  
131 provide elastic properties so that the force required for crumb deformation was smaller. The hardness  
132 value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.*  
133 (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to  
134 Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough.  
135 Dough made from high protein flour will have a strong and less elastic structure, due to the very strong  
136 intermolecular interactions. The bread has a firm texture and porous after baking. The addition of CMC  
137 can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 138 3.4 Springiness

139 The springiness value of the product has a positive correlation with elasticity. According to  
140 Mohammadi *et al.* (2014), the higher addition of CMC result in more elastic bread structure. According  
141 to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC  
142 increase was due to NaCMC having extended polymer chains that were dispersed in the solvent. The  
143 increase in polymer concentration makes the polymer chains increasingly difficult to separate from one  
144 another.

145 The results of the springiness test of bread enriched with rice bran can be observed in Table 1.  
146 The springiness value increases with the increased addition of CMC. The addition of CMC can affect  
147 springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread  
148 enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of  
149 NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran  
150 bread, the higher the springiness value.

### 151 3.5 Cohesiveness

152 Table 1 shows that the cohesiveness value increases with the increased addition of CMC.  
153 According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the  
154 tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact  
155 so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the  
156 addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network  
157 that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact  
158 with other components besides water such as protein because CMC has carboxyl groups that can join  
159 the positive charge groups of proteins. The bonds between CMC and other components can strengthen  
160 the structure of the bread.

161 *3.6 Preference of ease to bite*

162 The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The  
163 preference for ease to bite has a correlation with hardness. The hardness value describes the structural  
164 strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread  
165 structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite  
166 is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with  
167 rice bran is influenced by the strength of the bread structure. The strength of the bread structure is  
168 influenced by the shape of the structure of the bread itself. In general, what affects the structure of  
169 white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of  
170 the bread produced by bonding with the components in the dough such as water. The bond between  
171 CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in  
172 the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

173 *3.7 Preference of softness*

174 The preference scores of softness of bread enriched with rice bran softness can be observed in  
175 Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of  
176 CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller  
177 pore sizes and thin pore walls (Sciarini, 2012). Panelists prefer white bread with its characteristic thin  
178 and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls  
179 so that the resulting bread structure becomes softer.

180 *3.8 Preference of moistness*

181 The preference scores of moistness of bread enriched with rice bran can be observed in Table 2.  
182 The panelists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an  
183 average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the  
184 moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and  
185 improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture  
186 content. CMC has water binding properties. The higher CMC concentrations, hence the water bound in  
187 the bread tissue increases, thereby increasing the impression of moistness when the bread is consumed.

188

189 **4. Conclusion**

190 The increase in CMC concentration causes a decrease in moisture content, an increase in specific  
191 volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread  
192 enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to  
193 an increase preference in ease to bite, softness and moistness. The use of CMC improve the quality of  
194 bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

195

196 **Conflict of interest**

197 The authors declare no conflict of interest.

198

199 **Acknowledgments**

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203

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276 **Tables and Figures**

277 Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of  
278 CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27 <sup>c</sup>	3.29 <sup>b</sup>	724.86 <sup>e</sup>	0.92 <sup>a</sup>	0.64 <sup>a</sup>
0,5	42.26 <sup>c</sup>	2.96 <sup>a</sup>	683.64 <sup>d</sup>	0.92 <sup>ab</sup>	0.65 <sup>b</sup>
1	42.18 <sup>bc</sup>	3.40 <sup>c</sup>	557.14 <sup>c</sup>	0.93 <sup>ab</sup>	0.66 <sup>bc</sup>
1,5	42.05 <sup>b</sup>	3.55 <sup>d</sup>	451.13 <sup>b</sup>	0.93 <sup>bc</sup>	0.66 <sup>bc</sup>
2	41.79 <sup>a</sup>	3.61 <sup>e</sup>	326.93 <sup>a</sup>	0.95 <sup>c</sup>	0.67 <sup>c</sup>

279 \*Values are means ± standard deviations (n=3 for each group). Values in a column with the same letters  
280 are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA followed by  
281 DMRT test (α = 0.05).

282

283 Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79 <sup>ab</sup>	3.76 <sup>a</sup>	3.83 <sup>a</sup>
0.5	4.55 <sup>a</sup>	4.41 <sup>b</sup>	4.34 <sup>b</sup>
1	5.00 <sup>b</sup>	4.45 <sup>b</sup>	4.45 <sup>b</sup>
1.5	5.03 <sup>b</sup>	5.20 <sup>c</sup>	5.00 <sup>c</sup>
2	5.52 <sup>c</sup>	5.24 <sup>c</sup>	5.02 <sup>c</sup>

284 \*Values are means ± standard deviations (n=100 for each group). Values in a column with the same  
285 letters are not significantly (p>0.05) different. The statistical significance was evaluated by ANOVA  
286 followed by DMRT test (α = 0.05).

287

288



289

290 Figure 1. Cross section of of bread enriched with rice bran with different addition of CMC

291

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## **Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran**

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### **Abstract**

Bread enriched with rice bran is one of the innovative products of bread. The addition of 10% of rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran, increased specific volume, decreased hardness, increased springiness, increased cohesiveness, increased preference sensory properties ease to bite, softness, and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%, specific volume 3.61 cm<sup>3</sup>/g, hardness 326.93 g, springiness 0.95 mm, cohesiveness 0.67, preference for ease of bite 5.52 (slightly preferred), preference for softness 5.24 (slightly preferred), and preference for moistness 5.02 (slightly preferred).

**Keywords:** Bread enriched with rice bran, Carboxymethyl cellulose, Physicochemical properties, Sensory properties

### **1. Introduction**

Bread is one of the oldest and most popular sources of processed food products. Bread made from flour, water, yeast and other ingredients. The basic bread-making process includes kneading,

fermentation and baking. The high level of bread consumption and the increasing need for healthier food products have encouraged innovations in bakery products.

The addition of rice bran is one of the innovations in a bakery product. Rice bran is a by-product of the process of milling grain into rice and has developed into functional food. Rice bran contains a number of phenolic compounds, rich in dietary fibre, vitamins, minerals and essential amino acids (Henderson *et al.*, 2012).

Sairam *et al.* (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh *et al.* (2013) reported the results of the analysis of the crude fibre content of white bread substituted with rice bran as much as 10%, which was significantly different from control bread and bread substituted with 5% rice bran but there was no significant difference with the substitute of 15% rice bran. Trisnawati *et al.* (2019) reported that the addition of 10% rice bran to the plain bread formula had a significant effect on sensory properties but was still acceptable to the panellists.

The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and is rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting in bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was 10% of the total flour.

CMC is a derivative of cellulose and is often used in the food industry or used in food products to prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain moisture, improving the mouthfeel of the product, controlling sugar crystallization, controlling the rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability to bind free water. The CMC used in this study was Na-CMC.

This research aimed to study the effect of CMC concentrations on the physicochemical and sensory properties of bread enriched with rice bran.

## **2. Materials and methods**

### *2.1 Materials*

The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran, Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from the local market.

### *2.2 Bread formulation and processing*

Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar, 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1, consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of control ingredients with CMC at 4 g.

The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model) until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled, rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down at room temperature for 60 mins.

### 2.3 Experimental design

The experimental design used was a randomized block design (RBD) with one factor, namely the concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%; 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant effect on the results of the ANOVA, it was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the significantly different results.

### 2.4 Evaluation of bread enriched with rice bran characteristics

The parameters examined in this study include moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements are carried out one hour after baking with the formula:  $\text{specific volume (cm}^3/\text{g)} = \text{volume (cm}^3)/\text{weight of bread (g)}$ . After being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7-point scoring was used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained panellists participated in the sensory evaluation. Panellists had no previous or present taste or smell disorders. Each panellist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread samples were labelled with three-digit codes and randomly presented to avoid the bias of order of presentation.

## 3. Results and discussion

The results of the physicochemical properties testing which include moisture content, specific volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different concentrations of CMC can be seen in Table 1. The results of sensory properties which include preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in Table 2.



### 3.1 Moisture content

Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the water absorption rate in the bread dough, the lower the moisture content of the bread because the CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and hydroxyl groups from hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a three-dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain so that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread dough.

### 3.2 Specific volume

As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher the gas retention. During baking, there is an expansion of  $\text{CO}_2$  gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of bread is higher.

### 3.3 Hardness

Table 1. shows that the hardness value decreases with the increased addition of CMC. The addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. The hardness value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.* (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made from high protein flour will have a strong and less elastic structure, due to the very strong intermolecular interactions. The bread has a firm porous texture after baking. The addition of CMC can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 3.4 Springiness

The springiness value of the product has a positive correlation with elasticity. According to Mohammadi *et al.* (2014), the higher addition of CMC resulted in a more elastic bread structure. According to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase

was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in polymer concentration makes the polymer chains increasingly difficult to separate from one another.

The results of the springiness test of bread enriched with rice bran can be observed in Table 1. The springiness value increases with the increased addition of CMC. The addition of CMC can affect springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran bread, the higher the springiness value.

### 3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases with the increased addition of CMC. According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact with other components besides water such as protein because CMC has carboxyl groups that can join the positive charge groups of proteins. The bonds between CMC and other components can strengthen the structure of the bread.

### 3.6 Preference of ease to bite

The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The preference for ease to bite has a correlation with hardness. The hardness value describes the structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread structure is influenced by the shape of the structure of the bread itself. In general, what affects the structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of the bread produced by bonding with the components in the dough such as water. The bond between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

### 3.7 Preference of softness

The preference scores of the softness of bread enriched with rice bran softness can be observed in Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer.

### *3.8 Preference of moistness*

The preference scores of the moistness of bread enriched with rice bran can be observed in Table 2. The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture content. CMC has water-binding properties. The higher CMC concentrations, hence the water bound in the bread tissue increases, thereby increasing the impression of moistness when the bread is consumed.

### **Conclusion**

The increase in CMC concentration causes a decrease in moisture content, an increase in specific volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to an increasing preference in ease to bite, softness and moistness. The use of CMC improves the quality of bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

### **Conflict of interest**

The authors declare no conflict of interest.

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## Tables and Figures

Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27 <sup>c</sup>	3.29 <sup>b</sup>	724.86 <sup>e</sup>	0.92 <sup>a</sup>	0.64 <sup>a</sup>
0,5	42.26 <sup>c</sup>	2.96 <sup>a</sup>	683.64 <sup>d</sup>	0.92 <sup>ab</sup>	0.65 <sup>b</sup>
1	42.18 <sup>bc</sup>	3.40 <sup>c</sup>	557.14 <sup>c</sup>	0.93 <sup>ab</sup>	0.66 <sup>bc</sup>
1,5	42.05 <sup>b</sup>	3.55 <sup>d</sup>	451.13 <sup>b</sup>	0.93 <sup>bc</sup>	0.66 <sup>bc</sup>
2	41.79 <sup>a</sup>	3.61 <sup>e</sup>	326.93 <sup>a</sup>	0.95 <sup>c</sup>	0.67 <sup>c</sup>

\*Values are means  $\pm$  standard deviations (n=3 for each group). Values in a column with the same letters are not significantly ( $p>0.05$ ) different. The statistical significance was evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

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Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79 <sup>ab</sup>	3.76 <sup>a</sup>	3.83 <sup>a</sup>
0.5	4.55 <sup>a</sup>	4.41 <sup>b</sup>	4.34 <sup>b</sup>
1	5.00 <sup>b</sup>	4.45 <sup>b</sup>	4.45 <sup>b</sup>
1.5	5.03 <sup>b</sup>	5.20 <sup>c</sup>	5.00 <sup>c</sup>
2	5.52 <sup>c</sup>	5.24 <sup>c</sup>	5.02 <sup>c</sup>

\*Values are means  $\pm$  standard deviations (n=100 for each group). Values in a column with the same letters are not significantly ( $p > 0.05$ ) different. The statistical significance was evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

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Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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Sairam *et al.* (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh *et al.* (2013) reported the results of the analysis of the crude fibre content of white bread substituted with rice bran as much as 10%, which was significantly different from control bread and bread substituted with 5% rice bran but there was no significant difference with the substitute of 15% rice bran. Trisnawati *et al.* (2019) reported that the addition of 10% rice bran to the plain bread formula had a significant effect on sensory properties but was still acceptable to the panellists.

The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and is rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting in bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was 10% of the total flour.

CMC is a derivative of cellulose and is often used in the food industry or used in food products to prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain moisture, improving the mouthfeel of the product, controlling sugar crystallization, controlling the rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability to bind free water. The CMC used in this study was Na-CMC.

This research aimed to study the effect of CMC concentrations on the physicochemical and sensory properties of bread enriched with rice bran.

## **2. Materials and methods**

### *2.1 Materials*

The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran, Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from the local market.

### *2.2 Bread formulation and processing*

Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar, 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1, consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of control ingredients with CMC at 4 g.

The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model) until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled, rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down at room temperature for 60 mins.

### 2.3 Experimental design

The experimental design used was a randomized block design (RBD) with one factor, namely the concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%; 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant effect on the results of the ANOVA, it was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives the significantly different results.

### 2.4 Evaluation of bread enriched with rice bran characteristics

The parameters examined in this study include moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements are carried out one hour after baking with the formula:  $\text{specific volume (cm}^3/\text{g)} = \text{volume (cm}^3)/\text{weight of bread (g)}$ . After being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7-point scoring was used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained panellists participated in the sensory evaluation. Panellists had no previous or present taste or smell disorders. Each panellist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread samples were labelled with three-digit codes and randomly presented to avoid the bias of order of presentation.

## 3. Results and discussion

The results of the physicochemical properties testing which include moisture content, specific volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different concentrations of CMC can be seen in Table 1. The results of sensory properties which include preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in Table 2.

### 3.1 Moisture content

Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the water absorption rate in the bread dough, the lower the moisture content of the bread because the CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and hydroxyl groups from hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a three-dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain so that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread dough.

### 3.2 Specific volume

As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher the gas retention. During baking, there is an expansion of  $\text{CO}_2$  gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of bread is higher.

### 3.3 Hardness

Table 1. shows that the hardness value decreases with the increased addition of CMC. The addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. The hardness value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.* (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made from high protein flour will have a strong and less elastic structure, due to the very strong intermolecular interactions. The bread has a firm porous texture after baking. The addition of CMC can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 3.4 Springiness

The springiness value of the product has a positive correlation with elasticity. According to Mohammadi *et al.* (2014), the higher addition of CMC resulted in a more elastic bread structure. According to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase

was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in polymer concentration makes the polymer chains increasingly difficult to separate from one another.

The results of the springiness test of bread enriched with rice bran can be observed in Table 1. The springiness value increases with the increased addition of CMC. The addition of CMC can affect springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran bread, the higher the springiness value.

### 3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases with the increased addition of CMC. According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact with other components besides water such as protein because CMC has carboxyl groups that can join the positive charge groups of proteins. The bonds between CMC and other components can strengthen the structure of the bread.

### 3.6 Preference of ease to bite

The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The preference for ease to bite has a correlation with hardness. The hardness value describes the structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread structure is influenced by the shape of the structure of the bread itself. In general, what affects the structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of the bread produced by bonding with the components in the dough such as water. The bond between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

### 3.7 Preference of softness

The preference scores of the softness of bread enriched with rice bran softness can be observed in Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer.

### *3.8 Preference of moistness*

The preference scores of the moistness of bread enriched with rice bran can be observed in Table 2. The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture content. CMC has water-binding properties. The higher CMC concentrations, hence the water bound in the bread tissue increases, thereby increasing the impression of moistness when the bread is consumed.

### **Conclusion**

The increase in CMC concentration causes a decrease in moisture content, an increase in specific volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to an increasing preference in ease to bite, softness and moistness. The use of CMC improves the quality of bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

### **Conflict of interest**

The authors declare no conflict of interest.

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## Tables and Figures

Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27±0.00 <sup>c</sup>	3.29±0.01 <sup>b</sup>	724.86±5.99 <sup>e</sup>	0.92±0.00 <sup>a</sup>	0.64±0.03 <sup>a</sup>
0,5	42.26±0.00 <sup>c</sup>	2.96±0.02 <sup>a</sup>	683.64±22.02 <sup>d</sup>	0.92±0.01 <sup>ab</sup>	0.65±0.01 <sup>b</sup>
1	42.18±0.00 <sup>bc</sup>	3.40±0.02 <sup>c</sup>	557.14±10.39 <sup>c</sup>	0.93±0.02 <sup>ab</sup>	0.66±0.01 <sup>bc</sup>
1,5	42.05±0.00 <sup>b</sup>	3.55±0.03 <sup>d</sup>	451.13±5.85 <sup>b</sup>	0.93±0.01 <sup>bc</sup>	0.66±0.02 <sup>bc</sup>
2	41.79±0.00 <sup>a</sup>	3.61±0.02 <sup>e</sup>	326.93±27.12 <sup>a</sup>	0.95±0.01 <sup>c</sup>	0.67±0.02 <sup>c</sup>

\*Values are means (n=3 for each group). Values in a column with the same letters are not significantly ( $p>0.05$ ) different. The statistical significance was evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC\*

CMC Concentration (%)	Preference		
	Ease to bite	Softness	Moistness
0	4.79±1.24 <sup>ab</sup>	3.76±1.31 <sup>a</sup>	3.83±1.27 <sup>a</sup>
0.5	4.55±1.49 <sup>a</sup>	4.41±1.45 <sup>b</sup>	4.34±1.51 <sup>b</sup>
1	5.00±1.36 <sup>b</sup>	4.45±1.58 <sup>b</sup>	4.45±1.10 <sup>b</sup>
1.5	5.03±1.26 <sup>b</sup>	5.20±1.24 <sup>c</sup>	5.00±1.38 <sup>c</sup>
2	5.52±1.16 <sup>c</sup>	5.24±1.23 <sup>c</sup>	5.02±1.29 <sup>c</sup>

\*Values are means (n=100 for each group). Values in a column with the same letters are not significantly ( $p>0.05$ ) different. The statistical significance was evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).



Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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## Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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### Abstract

Bread enriched with rice bran is one of the innovative products of bread. The addition of 10% of rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran, increased specific volume, decreased hardness, increased springiness, increased cohesiveness, increased preference sensory properties ease to bite, softness, and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%, specific volume 3.61 cm<sup>3</sup>/g, hardness 326.93 g, springiness 0.95 mm, cohesiveness 0.67, preference for ease of bite 5.52 (slightly preferred), preference for softness 5.24 (slightly preferred), and preference for moistness 5.02 (slightly preferred).

## 1. Introduction

Bread is one of the oldest and most popular sources of processed food products. Bread made from flour, water, yeast and other ingredients. The basic bread-making process includes kneading, fermentation and baking. The high level of bread consumption and the increasing need for healthier food products have encouraged innovations in bakery products.

The addition of rice bran is one of the innovations in a bakery product. Rice bran is a by-product of the process of milling grain into rice and has developed into functional food. Rice bran contains a number of phenolic compounds, rich in dietary fibre, vitamins, minerals and essential amino acids (Henderson *et al.*, 2012).

Sairam *et al.* (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh *et al.* (2013) reported the results of the analysis of the crude fibre content of white bread substituted with rice bran as much as 10%, which was significantly different from control bread and bread substituted with 5% rice bran but

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The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and is rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting in bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was 10% of the total flour.

CMC is a derivative of cellulose and is often used in the food industry or used in food products to prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain moisture, improving the mouthfeel of the product, controlling

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sugar crystallization, controlling the rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability to bind free water. The CMC used in this study was Na-CMC.

This research aimed to study the effect of CMC concentrations on the physicochemical and sensory properties of bread enriched with rice bran.

## 2. Materials and methods

### 2.1 Materials

The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran, Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from the local market.

### 2.2 Bread formulation and processing

Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar, 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1, consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of control ingredients with CMC at 4 g.

The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model) until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled, rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down at room temperature for 60 mins.

### 2.3 Experimental design

The experimental design used was a randomized block design (RBD) with one factor, namely the concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%; 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there was a significant effect on the results of the ANOVA, it was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gave the significantly different

results.

### 2.4 Evaluation of bread enriched with rice bran characteristics

The parameters examined in this study included moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements were carried out one hour after baking with the formula: specific volume ( $\text{cm}^3/\text{g}$ ) = volume ( $\text{cm}^3$ )/weight of bread (g). After being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7-point scoring was used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained panellists participated in the sensory evaluation. Panellists had no previous or present taste or smell disorders. Each panellist received 5 pieces of bread enriched with rice bran samples with a size of  $2 \times 2 \times 1$  cm, bread samples were labelled with three-digit codes and randomly presented to avoid the bias of order of presentation.

## 3. Results and discussion

The results of the physicochemical properties testing which include moisture content, specific volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different concentrations of CMC can be seen in Table 1. The results of sensory properties which include preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in Table 2.

### 3.1 Moisture content

Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the water absorption rate in the bread dough, the lower the moisture content of the bread because the CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and hydroxyl groups from hydrocolloids will bind through hydrogen bonds and form a double helix conformation to form a three-

Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27±0.00 <sup>c</sup>	3.29±0.01 <sup>b</sup>	724.86±5.99 <sup>c</sup>	0.92±0.00 <sup>a</sup>	0.64±0.03 <sup>a</sup>
0.5	42.26±0.00 <sup>c</sup>	2.96±0.02 <sup>a</sup>	683.64±22.02 <sup>d</sup>	0.92±0.01 <sup>ab</sup>	0.65±0.01 <sup>b</sup>
1	42.18±0.00 <sup>bc</sup>	3.40±0.02 <sup>c</sup>	557.14±10.39 <sup>c</sup>	0.93±0.02 <sup>ab</sup>	0.66±0.01 <sup>bc</sup>
1.5	42.05±0.00 <sup>b</sup>	3.55±0.03 <sup>d</sup>	451.13±5.85 <sup>b</sup>	0.93±0.01 <sup>bc</sup>	0.66±0.02 <sup>bc</sup>
2	41.79±0.00 <sup>a</sup>	3.61±0.02 <sup>e</sup>	326.93±27.12 <sup>a</sup>	0.95±0.01 <sup>c</sup>	0.67±0.02 <sup>c</sup>

Values are presented as mean±SD (n = 3 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain so that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread dough.

### 3.2 Specific volume

As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume of bread enriched with rice bran increased. According to Kamal (2010), the presence of CMC in solution tends to form cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher the gas retention. During baking, there is an expansion of CO<sub>2</sub> gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of



Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

bread is higher.

### 3.3 Hardness

Table 1 shows that the hardness value decreases with

the increased addition of CMC. The addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. The hardness value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.* (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made from high protein flour will have a strong and less elastic structure, due to the very strong intermolecular interactions. The bread has a firm porous texture after baking. The addition of CMC can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 3.4 Springiness

The springiness value of the product has a positive correlation with elasticity. According to Mohammadi *et al.* (2014), the higher addition of CMC resulted in a more elastic bread structure. According to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in polymer concentration makes the polymer chains increasingly difficult to separate from one another.

The results of the springiness test of bread enriched with rice bran can be observed in Table 1. The springiness value increases with the increased addition of CMC. The addition of CMC can affect springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran bread, the higher the springiness value.

### 3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases

with the increased addition of CMC. According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact with other components besides water such as protein because CMC has carboxyl groups that can join the positive charge groups of proteins. The bonds between CMC and other components can strengthen the structure of the bread.

### 3.6 Preference of ease to bite

The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The preference for ease to bite has a correlation with hardness. The hardness value describes the structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread structure is influenced by the shape of the structure of the bread itself. In general, what affects the structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of the bread produced by bonding with the components in the dough such as water. The bond between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

### 3.7 Preference of softness

The preference scores of the softness of bread enriched with rice bran softness can be observed in Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer.

### 3.8 Preference of moistness

The preference scores of the moistness of bread

enriched with rice bran can be observed in Table 2. The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture content. CMC has water-binding properties. The higher CMC concentrations, hence the water bound in the bread tissue increases, thereby increasing the impression of moistness when the

Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Ease to bite	Preference Softness	Moistness
0	4.79±1.24 <sup>ab</sup>	3.76±1.31 <sup>a</sup>	3.83±1.27 <sup>a</sup>
0.5	4.55±1.49 <sup>a</sup>	4.41±1.45 <sup>b</sup>	4.34±1.51 <sup>b</sup>
1	5.00±1.36 <sup>b</sup>	4.45±1.58 <sup>b</sup>	4.45±1.10 <sup>b</sup>
1.5	5.03±1.26 <sup>b</sup>	5.20±1.24 <sup>c</sup>	5.00±1.38 <sup>c</sup>
2	5.52±1.16 <sup>c</sup>	5.24±1.23 <sup>c</sup>	5.02±1.29 <sup>c</sup>

Values are presented as mean±SD (n = 100 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

bread is consumed.

## 4. Conclusion

The increase in CMC concentration causes a decrease in moisture content, an increase in specific volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to an increasing preference in ease to bite, softness and moistness. The use of CMC improves the quality of bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

## Conflict of interest

The authors declare no conflict of interest.

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## Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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### Abstract

Bread enriched with rice bran is one of the innovative products of bread. The addition of 10% of rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran, increased specific volume, decreased hardness, increased springiness, increased cohesiveness, increased preference sensory properties ease to bite, softness, and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%, specific volume 3.61 cm<sup>3</sup>/g, hardness 326.93 g, springiness 0.95 mm, cohesiveness 0.67, preference for ease of bite 5.52 (slightly preferred), preference for softness 5.24 (slightly preferred), and preference for moistness 5.02 (slightly preferred).

## 1. Introduction

Bread is one of the oldest and most popular sources of processed food products. Bread made from flour, water, yeast and other ingredients. The basic bread-making process includes kneading, fermentation and baking. The high level of bread consumption and the increasing need for healthier food products have encouraged innovations in bakery products.

The addition of rice bran is one of the innovations in a bakery product. Rice bran is a by-product of the process of milling grain into rice and has developed into functional food. Rice bran contains a number of phenolic compounds, rich in dietary fibre, vitamins, minerals and essential amino acids (Henderson *et al.*, 2012).

Sairam *et al.* (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh *et al.* (2013) reported the results of the analysis of the crude fibre content of white bread substituted with rice bran as much as 10%, which was significantly different from control bread and bread substituted with 5% rice bran but

there was no significant difference with the substitute of 15% rice bran. Trisnawati *et al.* (2019) reported that the addition of 10% rice bran to the plain bread formula had a significant effect on sensory properties but was still acceptable to the panellists.

The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and is rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting in bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was 10% of the total flour.

CMC is a derivative of cellulose and is often used in the food industry or used in food products to prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain moisture, improving the mouthfeel of the product, controlling

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sugar crystallization, controlling the rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability to bind free water. The CMC used in this study was Na-CMC.

This research aimed to study the effect of CMC concentrations on the physicochemical and sensory properties of bread enriched with rice bran.

## 2. Materials and methods

### 2.1 Materials

The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran, Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from the local market.

### 2.2 Bread formulation and processing

Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar, 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1, consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of control ingredients with CMC at 4 g.

The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model) until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled, rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down at room temperature for 60 mins.

### 2.3 Experimental design

The experimental design used was a randomized block design (RBD) with one factor, namely the concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%; 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there is a significant effect on the results of the ANOVA, it was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gives significantly different

results.

### 2.4 Evaluation of bread enriched with rice bran characteristics

The parameters examined in this study include moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements are carried out one hour after baking with the formula: specific volume ( $\text{cm}^3/\text{g}$ ) = volume ( $\text{cm}^3$ )/weight of bread (g). After being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7-point scoring was used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained panellists participated in the sensory evaluation. Panellists had no previous or present taste or smell disorders. Each panellist received 5 pieces of bread enriched with rice bran samples with a size of  $2 \times 2 \times 1$  cm, bread samples were labelled with three-digit codes and randomly presented to avoid the bias of order of presentation.

## 3. Results and discussion

The results of the physicochemical properties testing which include moisture content, specific volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different concentrations of CMC can be seen in Table 1. The results of sensory properties which include preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in Table 2.

### 3.1 Moisture content

Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the water absorption rate in the bread dough, the lower the moisture content of the bread because the CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and hydroxyl groups from hydrocolloids will bond through hydrogen bonds and form a double helix conformation to form a three-

Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27±0.00 <sup>c</sup>	3.29±0.01 <sup>b</sup>	724.86±5.99 <sup>c</sup>	0.92±0.00 <sup>a</sup>	0.64±0.03 <sup>a</sup>
0.5	42.26±0.00 <sup>c</sup>	2.96±0.02 <sup>a</sup>	683.64±22.02 <sup>d</sup>	0.92±0.01 <sup>ab</sup>	0.65±0.01 <sup>b</sup>
1	42.18±0.00 <sup>bc</sup>	3.40±0.02 <sup>c</sup>	557.14±10.39 <sup>c</sup>	0.93±0.02 <sup>ab</sup>	0.66±0.01 <sup>bc</sup>
1.5	42.05±0.00 <sup>b</sup>	3.55±0.03 <sup>d</sup>	451.13±5.85 <sup>b</sup>	0.93±0.01 <sup>bc</sup>	0.66±0.02 <sup>bc</sup>
2	41.79±0.00 <sup>a</sup>	3.61±0.02 <sup>e</sup>	326.93±27.12 <sup>a</sup>	0.95±0.01 <sup>c</sup>	0.67±0.02 <sup>c</sup>

Values are presented as mean±SD (n = 3 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain so that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread dough.

### 3.2 Specific volume

As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume of rice bran bread increased. According to Kamal (2010), the presence of CMC in solution tends to form cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher the gas retention. During baking, there is an expansion of CO<sub>2</sub> gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of bread is higher.



Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

### 3.3 Hardness

Table 1 shows that the hardness value decreases with the increased addition of CMC. The addition of CMC

resulted in the decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. The hardness value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.* (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made from high protein flour will have a strong and less elastic structure, due to the very strong intermolecular interactions. The bread has a firm porous texture after baking. The addition of CMC can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 3.4 Springiness

The springiness value of the product has a positive correlation with elasticity. According to Mohammadi *et al.* (2014), the higher addition of CMC resulted in a more elastic bread structure. According to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in polymer concentration makes the polymer chains increasingly difficult to separate from one another.

The results of the springiness test of bread enriched with rice bran can be observed in Table 1. The springiness value increases with the increased addition of CMC. The addition of CMC can affect springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran bread, the higher the springiness value.

### 3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases with the increased addition of CMC. According to

Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact with other components besides water such as protein because CMC has carboxyl groups that can join the positive charge groups of proteins. The bonds between CMC and other components can strengthen the structure of the bread.

### 3.6 Preference of ease to bite

The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The preference for ease to bite has a correlation with hardness. The hardness value describes the structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread structure is influenced by the shape of the structure of the bread itself. In general, what affects the structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of the bread produced by bonding with the components in the dough such as water. The bond between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

### 3.7 Preference of softness

The preference scores of the softness of bread enriched with rice bran softness can be observed in Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer.

### 3.8 Preference of moistness

The preference scores of the moistness of bread enriched with rice bran can be observed in Table 2. The

panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture content. CMC has water-binding properties. The higher CMC concentrations, hence the water bound in the bread tissue increases, thereby increasing the impression of moistness when the bread is consumed.

Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Ease to bite	Preference Softness	Moistness
0	4.79±1.24 <sup>ab</sup>	3.76±1.31 <sup>a</sup>	3.83±1.27 <sup>a</sup>
0.5	4.55±1.49 <sup>a</sup>	4.41±1.45 <sup>b</sup>	4.34±1.51 <sup>b</sup>
1	5.00±1.36 <sup>b</sup>	4.45±1.58 <sup>b</sup>	4.45±1.10 <sup>b</sup>
1.5	5.03±1.26 <sup>b</sup>	5.20±1.24 <sup>c</sup>	5.00±1.38 <sup>c</sup>
2	5.52±1.16 <sup>c</sup>	5.24±1.23 <sup>c</sup>	5.02±1.29 <sup>c</sup>

Values are presented as mean±SD (n = 100 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

## 4. Conclusion

The increase in CMC concentration causes a decrease in moisture content, an increase in specific volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to an increasing preference in ease to bite, softness and moistness. The use of CMC improves the quality of bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

### Conflict of interest

The authors declare no conflict of interest.

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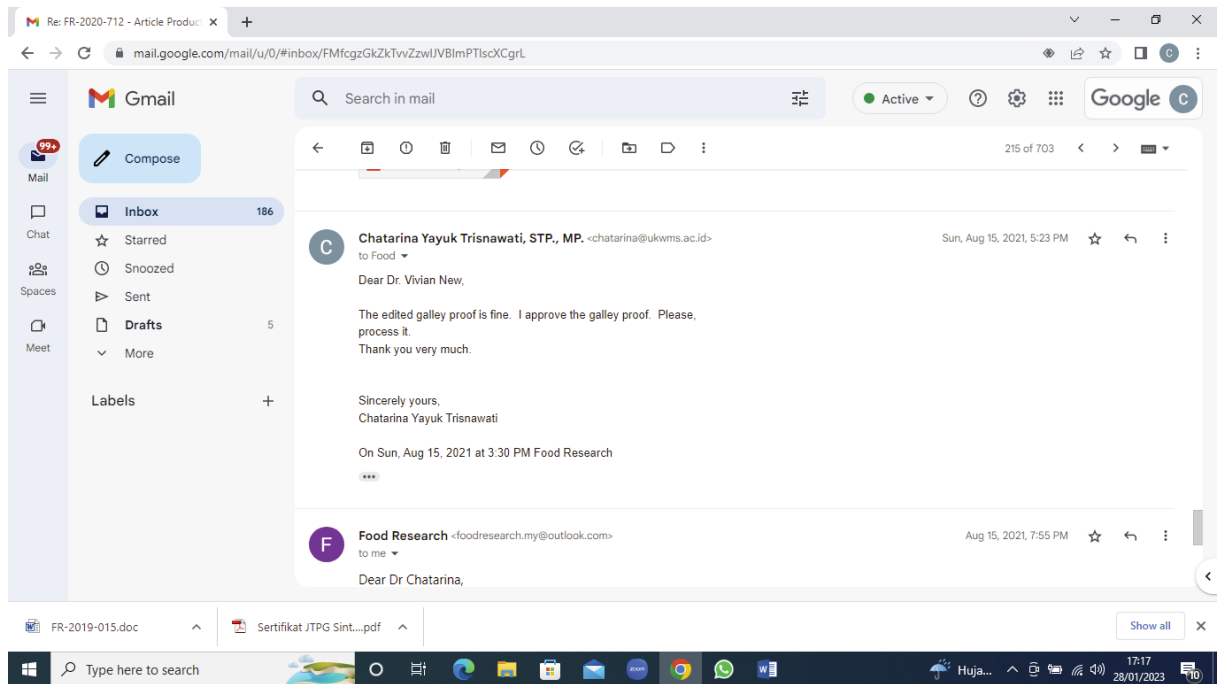
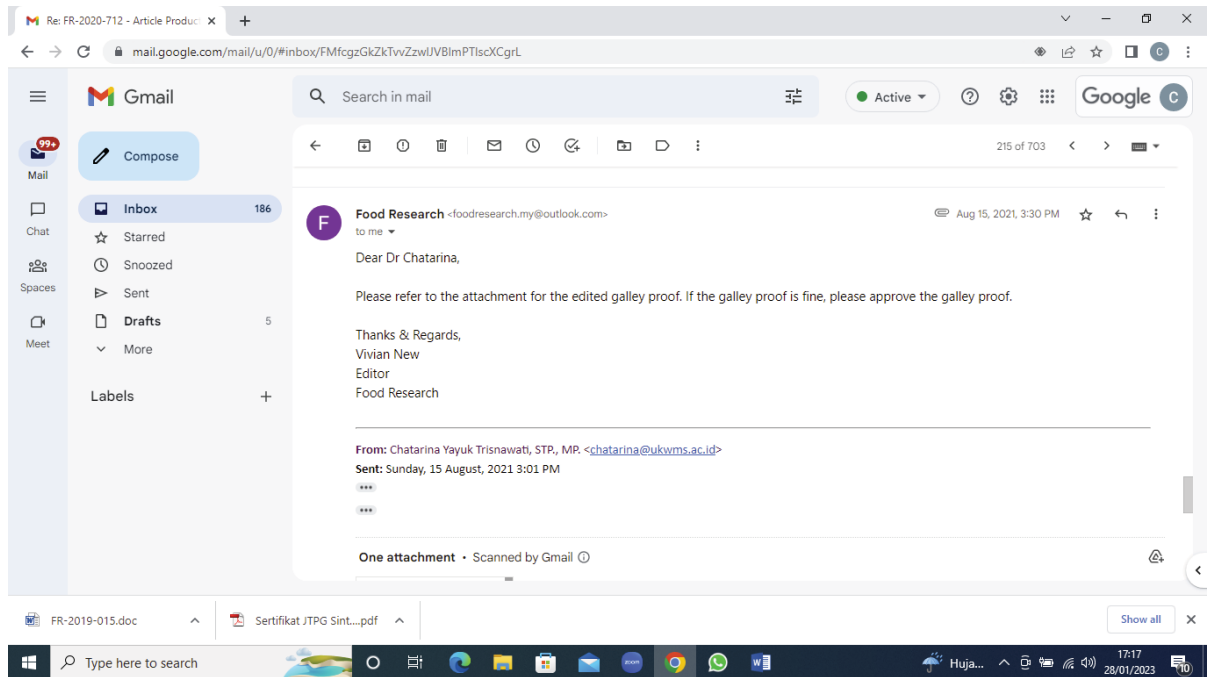
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## Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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### Abstract

Bread enriched with rice bran is one of the innovative products of bread. The addition of 10% of rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran, increased specific volume, decreased hardness, increased springiness, increased cohesiveness, increased preference sensory properties ease to bite, softness, and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%, specific volume 3.61 cm<sup>3</sup>/g, hardness 326.93 g, springiness 0.95 mm, cohesiveness 0.67, preference for ease of bite 5.52 (slightly preferred), preference for softness 5.24 (slightly preferred), and preference for moistness 5.02 (slightly preferred).

## 1. Introduction

Bread is one of the oldest and most popular sources of processed food products. Bread made from flour, water, yeast and other ingredients. The basic bread-making process includes kneading, fermentation and baking. The high level of bread consumption and the increasing need for healthier food products have encouraged innovations in bakery products.

The addition of rice bran is one of the innovations in a bakery product. Rice bran is a by-product of the process of milling grain into rice and has developed into functional food. Rice bran contains a number of phenolic compounds, rich in dietary fibre, vitamins, minerals and essential amino acids (Henderson *et al.*, 2012).

Sairam *et al.* (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh *et al.* (2013) reported the results of the analysis of the crude fibre content of white bread substituted with rice bran as much as 10%, which was significantly different from control bread and bread substituted with 5% rice bran but

there was no significant difference with the substitute of 15% rice bran. Trisnawati *et al.* (2019) reported that the addition of 10% rice bran to the plain bread formula had a significant effect on sensory properties but was still acceptable to the panellists.

The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and is rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting in bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). Qadri *et al.* (2018) have used 1% - 3% of CMC to improve the quality of gluten-free bakery products. The rice bran added to this research was 10% of the total flour.

CMC is a derivative of cellulose and is often used in the food industry or used in food products to prevent starch retrogradation (Chinachoti, 1995). CMC is generally used in baked products to retain moisture, improving the mouthfeel of the product, controlling

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sugar crystallization, controlling the rheological properties of dough, increasing the development volume (Kohajdová and Karovičová, 2009). CMC is able to increase the swelling volume by increasing the viscosity of the dough because of its ability to bind free water. The CMC used in this study was Na-CMC.

This research aimed to study the effect of CMC concentrations on the physicochemical and sensory properties of bread enriched with rice bran.

## 2. Materials and methods

### 2.1 Materials

The main ingredients to make bread enriched with rice bran bread consist of wheat flour, rice bran, Na-CMC (Natrium Carboxymethylcellulose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from the local market.

### 2.2 Bread formulation and processing

Five bread formulas were: 1) control, consist of 180 g of wheat flour, 20 g of rice bran, 10 g of sugar, 8 g of margarine, 2 g of salt, 0.6 g of bread improver, 3 g of instant yeast and 124 g of water; 2) C1, consist of those of control ingredients with CMC at 1 g; 3) C2, consist of those of control ingredients with CMC at 2 g; 4) C3, consist of those of control ingredients with CMC at 3 g; and 5) C4, consist of those of control ingredients with CMC at 4 g.

The dry ingredients were mixed with water, margarine, and salt in a mixer (Phillips HR 1559 model) until it becomes a viscoelastic dough and then, fermented at ambient for 30 mins. The dough was rolled, rounded and placed in a baking dish, and baked in an oven (Gas Bakery Oven RFL-12C model) at 180°C for 30 mins. The finished bread enriched with rice bran is removed from the bread pan and cooled down at room temperature for 60 mins.

### 2.3 Experimental design

The experimental design used was a randomized block design (RBD) with one factor, namely the concentration of CMC (C). The CMC concentration factor consists of 5 levels, namely 0%; 0.5%; 1%; 1.5%; and 2% of the total weight of flour and bran used. The experiment was replicated five times. Data were analyzed statistically using ANOVA (Analysis of Variance) at  $\alpha = 5\%$  to determine whether the treatment had a significant effect. If there was a significant effect on the results of the ANOVA, it was followed by Duncan's Multiple Range Test (DMRT) at  $\alpha = 5\%$  to find out which treatment level gave the significantly different

results.

### 2.4 Evaluation of bread enriched with rice bran characteristics

The parameters examined in this study included moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content was measured with the thermogravimetric method (AOAC 925.10). Specific volume measurements were carried out one hour after baking with the formula: specific volume ( $\text{cm}^3/\text{g}$ ) = volume ( $\text{cm}^3$ )/weight of bread (g). After being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004). Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-XT Plus according to Gomez *et al.* (2007). A sensory evaluation which includes ease to bite, softness, and moistness was conducted by using the hedonic method (Stone and Sidel, 2004). A 7-point scoring was used with 1 representing extremely dislike and 7 representing extremely like. One hundred untrained panellists participated in the sensory evaluation. Panellists had no previous or present taste or smell disorders. Each panellist received 5 pieces of bread enriched with rice bran samples with a size of  $2 \times 2 \times 1$  cm, bread samples were labelled with three-digit codes and randomly presented to avoid the bias of order of presentation.

## 3. Results and discussion

The results of the physicochemical properties testing which include moisture content, specific volume, hardness, springiness, and cohesiveness of bread enriched with rice bran with different concentrations of CMC can be seen in Table 1. The results of sensory properties which include preference of ease to bite, softness, and moistness of rice bran bread with differences in CMC concentrations can be seen in Table 2.

### 3.1 Moisture content

Table 1 shows the decrease of moisture content with the higher addition of CMC. The higher the water absorption rate in the bread dough, the lower the moisture content of the bread because the CMC will bind more water. In the bread enriched with rice bran production, CMC is used in the form of NaCMC. When NaCMC is dispersed in water,  $\text{Na}^+$  will be released and replaced with  $\text{H}^+$  ions and form HCMC which increases the viscosity (Bochek *et al.*, 2002). According to Fennema (1996), water and hydroxyl groups from hydrocolloids will bind through hydrogen bonds and form a double helix conformation to form a three-

Table 1. Physicochemical properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Moisture Content (g)	Specific Volume (cm <sup>3</sup> /g)	Hardness (g)	Springiness (mm)	Cohesiveness
0	42.27±0.00 <sup>c</sup>	3.29±0.01 <sup>b</sup>	724.86±5.99 <sup>c</sup>	0.92±0.00 <sup>a</sup>	0.64±0.03 <sup>a</sup>
0.5	42.26±0.00 <sup>c</sup>	2.96±0.02 <sup>a</sup>	683.64±22.02 <sup>d</sup>	0.92±0.01 <sup>ab</sup>	0.65±0.01 <sup>b</sup>
1	42.18±0.00 <sup>bc</sup>	3.40±0.02 <sup>c</sup>	557.14±10.39 <sup>c</sup>	0.93±0.02 <sup>ab</sup>	0.66±0.01 <sup>bc</sup>
1.5	42.05±0.00 <sup>b</sup>	3.55±0.03 <sup>d</sup>	451.13±5.85 <sup>b</sup>	0.93±0.01 <sup>bc</sup>	0.66±0.02 <sup>bc</sup>
2	41.79±0.00 <sup>a</sup>	3.61±0.02 <sup>e</sup>	326.93±27.12 <sup>a</sup>	0.95±0.01 <sup>c</sup>	0.67±0.02 <sup>c</sup>

Values are presented as mean±SD (n = 3 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

dimensional structure. The mechanism for the formation of NaCMC gel is through the entanglement process (polymer chain extension), after the NaCMC is dispersed in water, the polymer chain from NaCMC will undergo an extension and will form an irregular polymer chain so that water will be trapped in the polymer chain formed (Allen, 2002). According to research by Sidhu and Bawa (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate of bread dough.

### 3.2 Specific volume

As shown in Figure 1, it can be observed that the higher concentration of CMC specific volume of bread enriched with rice bran increased. According to Kamal (2010), the presence of CMC in solution tends to form cross-bonds in polymer molecules which cause solvent molecules to be trapped in them, resulting in immobilization of solvent molecules which can form a molecular structure that is rigid and resistant to pressure. Table 1 shows the increase of specific volume with the higher addition of CMC. The higher the concentration of CMC added, the value of elasticity and extensibility of the dough will increase. The increase in extensibility and elasticity of this bread dough will result in the ability of the dough to trap gas to be better. According to the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher the gas retention. During baking, there is an expansion of CO<sub>2</sub> gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of



Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

bread is higher.

### 3.3 Hardness

Table 1 shows that the hardness value decreases with

the increased addition of CMC. The addition of CMC resulted in the decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. The hardness value is influenced by crumb porosity and is related to a specific volume. According to Sciarini *et al.* (2012), the addition of CMC was able to reduce the porosity of the crumb structure. According to Tronsmo *et al.* (2003), the porosity of bread is determined by the rheological properties of the dough. Dough made from high protein flour will have a strong and less elastic structure, due to the very strong intermolecular interactions. The bread has a firm porous texture after baking. The addition of CMC can increase the viscoelasticity of bread dough so that the bread becomes more easily deformed.

### 3.4 Springiness

The springiness value of the product has a positive correlation with elasticity. According to Mohammadi *et al.* (2014), the higher addition of CMC resulted in a more elastic bread structure. According to Gruber (1999) who examined polymers, the increase in elasticity as the concentration of CMC increase was due to NaCMC having extended polymer chains that were dispersed in the solvent. The increase in polymer concentration makes the polymer chains increasingly difficult to separate from one another.

The results of the springiness test of bread enriched with rice bran can be observed in Table 1. The springiness value increases with the increased addition of CMC. The addition of CMC can affect springiness because the addition of hydrocolloid can increase the elasticity of the pore walls of bread enriched with rice bran. According to Yuliani (2012), hydrogen bonding can reduce the solubility of NaCMC in water and produce elastic hydrogel formation. The higher the elastic pore walls of rice bran bread, the higher the springiness value.

### 3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases

with the increased addition of CMC. According to Kilcast (2004), cohesiveness is influenced by the moisture content and strength of the tissue around the crumb pores. The large cohesiveness value indicates that the bread is more compact so that the bread is not easily crushed during the processing. According to Lazaridou *et al.* (2007), the addition of CMC increases the cohesiveness of bread. This is due to the ability of CMC to form a network that can unite the components of bread dough. According to Imeson (2010), CMC is also able to interact with other components besides water such as protein because CMC has carboxyl groups that can join the positive charge groups of proteins. The bonds between CMC and other components can strengthen the structure of the bread.

### 3.6 Preference of ease to bite

The preference scores of ease to bite of bread enriched with rice bran can be seen in Table 2. The preference for ease to bite has a correlation with hardness. The hardness value describes the structural strength of the bread enriched with rice bran. The higher the hardness value, the stronger the bread structure, making it harder to bite. It can be observed in Table 1 and Table 2 the value of the ease to bite is inversely correlated to the value of the hardness of the bread. The ease to bite of bread enriched with rice bran is influenced by the strength of the bread structure. The strength of the bread structure is influenced by the shape of the structure of the bread itself. In general, what affects the structure of white bread is the tissue formed by gluten during baking. The addition of CMC affects the structure of the bread produced by bonding with the components in the dough such as water. The bond between CMC and water creates an easy-to-bite texture of the bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.

### 3.7 Preference of softness

The preference scores of the softness of bread enriched with rice bran softness can be observed in Table 2. The softness preference scores range between 5.20-5.24 (slightly preferred). The addition of CMC affects the softness of bread. This is due to the addition of CMC to produce bread with smaller pore sizes and thin pore walls (Sciarini, 2012). Panellists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer.

### 3.8 Preference of moistness

The preference scores of the moistness of bread

enriched with rice bran can be observed in Table 2. The panellists preferred bread enriched with rice bran of moistness at 1.5-2% CMC concentration with an average sensory test value of 5-5.02 (slightly preferred). The addition of 2% CMC resulted in the moistest bread. According to Chinachoti (1995), the addition of CMC is able to retain moisture and improve the mouthfeel of bakery products. The moistness of bread has a correlation with moisture content. CMC has water-binding properties. The higher CMC concentrations, hence the water bound in the bread tissue increases, thereby increasing the impression of moistness when the

Table 2. Sensory properties of bread enriched with rice bran with different concentrations of CMC

CMC Concentration (%)	Ease to bite	Preference Softness	Moistness
0	4.79±1.24 <sup>ab</sup>	3.76±1.31 <sup>a</sup>	3.83±1.27 <sup>a</sup>
0.5	4.55±1.49 <sup>a</sup>	4.41±1.45 <sup>b</sup>	4.34±1.51 <sup>b</sup>
1	5.00±1.36 <sup>b</sup>	4.45±1.58 <sup>b</sup>	4.45±1.10 <sup>b</sup>
1.5	5.03±1.26 <sup>b</sup>	5.20±1.24 <sup>c</sup>	5.00±1.38 <sup>c</sup>
2	5.52±1.16 <sup>c</sup>	5.24±1.23 <sup>c</sup>	5.02±1.29 <sup>c</sup>

Values are presented as mean±SD (n = 100 for each group). Values with the same superscript within the column are not significantly (p>0.05) different evaluated by ANOVA followed by DMRT test ( $\alpha = 0.05$ ).

bread is consumed.

## 4. Conclusion

The increase in CMC concentration causes a decrease in moisture content, an increase in specific volume, a decrease in hardness, an increase in springiness, and an increase in the cohesiveness of bread enriched with rice bran. Based on the preference sensory test, the increase in CMC concentration led to an increasing preference in ease to bite, softness and moistness. The use of CMC improves the quality of bread enriched with 10% of rice bran. The best treatment was 2% CMC addition.

## Conflict of interest

The authors declare no conflict of interest.

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