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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 (cm^3 / g) = volume (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, Na^+ will be released and replaced with 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 CO₂ 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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|-------------------------|---|---------------------|---------------------|--------------------|
| 0 | 42.27 ^c | 3.29 ^b | 724.86 ^e | 0.92 ^a | 0.64 ^a |
| 0,5 | 42.26 ^c | 2.96 ^a | 683.64 ^d | 0.92 ^{ab} | 0.65 ^b |
| 1 | 42.18 ^{bc} | 3.40 ^c | 557.14 ^c | 0.93 ^{ab} | 0.66 ^{bc} |
| 1,5 | 42.05 ^b | 3.55 ^d | 451.13 ^b | 0.93 ^{bc} | 0.66 ^{bc} |
| 2 | 41.79 ^a | 3.61 ^e | 326.93 ^a | 0.95 ^c | 0.67 ^c |

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 ^{ab} | 3.76 ^a | 3.83 ^a |
| 0.5 | 4.55 ^a | 4.41 ^b | 4.34 ^b |
| 1 | 5.00 ^b | 4.45 ^b | 4.45 ^b |
| 1.5 | 5.03 ^b | 5.20 ^c | 5.00 ^c |
| 2 | 5.52 ^c | 5.24 ^c | 5.02 ^c |

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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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 (cm^3 / g) = volume (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, Na^+ will be released and replaced with 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 CO₂ 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

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255 [_Fungsional_Peluang_Hambatan_dan_Tantangan](https://www.researchgate.net/publication/320842744_Pengembangan_Bekatul_sebagai_Pangan_Fungsional_Peluang_Hambatan_dan_Tantangan).

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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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|-------------------------|---|---------------------|---------------------|--------------------|
| 0 | 42.27 ^c | 3.29 ^b | 724.86 ^e | 0.92 ^a | 0.64 ^a |
| 0,5 | 42.26 ^c | 2.96 ^a | 683.64 ^d | 0.92 ^{ab} | 0.65 ^b |
| 1 | 42.18 ^{bc} | 3.40 ^c | 557.14 ^c | 0.93 ^{ab} | 0.66 ^{bc} |
| 1,5 | 42.05 ^b | 3.55 ^d | 451.13 ^b | 0.93 ^{bc} | 0.66 ^{bc} |
| 2 | 41.79 ^a | 3.61 ^e | 326.93 ^a | 0.95 ^c | 0.67 ^c |

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 ^{ab} | 3.76 ^a | 3.83 ^a |
| 0.5 | 4.55 ^a | 4.41 ^b | 4.34 ^b |
| 1 | 5.00 ^b | 4.45 ^b | 4.45 ^b |
| 1.5 | 5.03 ^b | 5.20 ^c | 5.00 ^c |
| 2 | 5.52 ^c | 5.24 ^c | 5.02 ^c |

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

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3.

Bukti konfirmasi review dan hasil review dari Reviewer II

(22 Januari 2021)

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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 cm³/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 sources 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
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79 dough (g). After being weighed, the sample volume was measured using barley according to Lopez et al.

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84 panelists participated in the sensory evaluation. Panelists had no previous or present taste or smell
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95 3.1 Moisture Content

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100 three-dimensional structure. The mechanism for the formation of NaCMC gel is through the
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102 chain from NaCMC will undergo an extension and will form an irregular polymer chain, so that water will
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104 (2000), the addition of CMC 0.1-0.5% was able to have a significant effect on the water absorption rate
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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
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120 3.3 Hardness

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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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|-------------------------|---|---------------------|---------------------|--------------------|
| 0 | 42.27 ^c | 3.29 ^b | 724.86 ^e | 0.92 ^a | 0.64 ^a |
| 0,5 | 42.26 ^c | 2.96 ^a | 683.64 ^d | 0.92 ^{ab} | 0.65 ^b |
| 1 | 42.18 ^{bc} | 3.40 ^c | 557.14 ^c | 0.93 ^{ab} | 0.66 ^{bc} |
| 1,5 | 42.05 ^b | 3.55 ^d | 451.13 ^b | 0.93 ^{bc} | 0.66 ^{bc} |
| 2 | 41.79 ^a | 3.61 ^e | 326.93 ^a | 0.95 ^c | 0.67 ^c |

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 ^{ab} | 3.76 ^a | 3.83 ^a |
| 0.5 | 4.55 ^a | 4.41 ^b | 4.34 ^b |
| 1 | 5.00 ^b | 4.45 ^b | 4.45 ^b |
| 1.5 | 5.03 ^b | 5.20 ^c | 5.00 ^c |
| 2 | 5.52 ^c | 5.24 ^c | 5.02 ^c |

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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1 **Effect of Carboxymethyl Cellulose on the Physicochemical and Sensory Properties of**
2 **Bread Enriched with Rice Bran**

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 innovative products of bread. The addition of 10% rice bran
10 into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice
11 bran being harder. Texture and volume development problems in the making of bread enriched with
12 rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the
13 effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice
14 bran. The research design was a Randomized Block Design consisting of one factor which was the CMC
15 concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed
16 that increasing CMC concentration decreased moisture content in bread enriched with rice bran;
17 increased specific volume; decreased hardness; increased springiness; increased cohesiveness;
18 increased preference sensory properties ease to bite; softness; and moistness. The best treatment was
19 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content
20 41.79%; specific volume 3.61 cm³/g; hardness 326.93 g; springiness 0.95 mm; cohesiveness 0,67;
21 preference for ease of bite 5.52 (slightly preferred); preference for softness 5.24 (slightly preferred); and
22 preference for moistness 5.02 (slightly preferred).

23 **Keywords:** bread enriched with rice bran, carboxymethyl cellulose, physicochemical properties, sensory
24 properties

25
26 **1. Introduction**

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

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

35 Sairam, Khrisna, and Urooj (2011) have added rice bran as much as 5% and 10% into bread and
36 produced bread with acceptable physicochemical properties. Ameh, Gernah, and Igbabul (2013)

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,
62 margarine, instant yeast, and bread improver were obtained from the local market.

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 (cm^3 / g) = volume (cm^3) / weight of bread (g). After
87 being weighed, the sample volume was measured using barley according to Lopez *et al.* (2004).
88 Hardness, springiness, and cohesiveness were evaluated by using Texture Analyzer TA-Xt Plus according
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, Na^+ will be released and replaced with 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 CO₂ 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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202 contract number 200 AH/WM01.5/N/2019.

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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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|-------------------------|---|---------------------|---------------------|--------------------|
| 0 | 42.27 ^c | 3.29 ^b | 724.86 ^e | 0.92 ^a | 0.64 ^a |
| 0,5 | 42.26 ^c | 2.96 ^a | 683.64 ^d | 0.92 ^{ab} | 0.65 ^b |
| 1 | 42.18 ^{bc} | 3.40 ^c | 557.14 ^c | 0.93 ^{ab} | 0.66 ^{bc} |
| 1,5 | 42.05 ^b | 3.55 ^d | 451.13 ^b | 0.93 ^{bc} | 0.66 ^{bc} |
| 2 | 41.79 ^a | 3.61 ^e | 326.93 ^a | 0.95 ^c | 0.67 ^c |

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 ^{ab} | 3.76 ^a | 3.83 ^a |
| 0.5 | 4.55 ^a | 4.41 ^b | 4.34 ^b |
| 1 | 5.00 ^b | 4.45 ^b | 4.45 ^b |
| 1.5 | 5.03 ^b | 5.20 ^c | 5.00 ^c |
| 2 | 5.52 ^c | 5.24 ^c | 5.02 ^c |

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

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289

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

291

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Authors : Harsono, C., Trisnawati, C.Y., Srianta, I., Nugerahani, I. and Marsono, Y.

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

Harsono, C., *Trisnawati, C.Y., Srinta, I., Nugerahani, I. and Marsono, Y.

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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 cm³/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, Na^+ will be released and replaced with 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 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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|----------------------|--------------------------------------|---------------------|--------------------|--------------------|
| 0 | 42.27 ^c | 3.29 ^b | 724.86 ^e | 0.92 ^a | 0.64 ^a |
| 0,5 | 42.26 ^c | 2.96 ^a | 683.64 ^d | 0.92 ^{ab} | 0.65 ^b |
| 1 | 42.18 ^{bc} | 3.40 ^c | 557.14 ^c | 0.93 ^{ab} | 0.66 ^{bc} |
| 1,5 | 42.05 ^b | 3.55 ^d | 451.13 ^b | 0.93 ^{bc} | 0.66 ^{bc} |
| 2 | 41.79 ^a | 3.61 ^e | 326.93 ^a | 0.95 ^c | 0.67 ^c |

*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 ^{ab} | 3.76 ^a | 3.83 ^a |
| 0.5 | 4.55 ^a | 4.41 ^b | 4.34 ^b |
| 1 | 5.00 ^b | 4.45 ^b | 4.45 ^b |
| 1.5 | 5.03 ^b | 5.20 ^c | 5.00 ^c |
| 2 | 5.52 ^c | 5.24 ^c | 5.02 ^c |

*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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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 cm³/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

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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_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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|--------------------------|--------------------------------------|---------------------------|-------------------------|-------------------------|
| 0 | 42.27±0.00 ^c | 3.29±0.01 ^b | 724.86±5.99 ^e | 0.92±0.00 ^a | 0.64±0.03 ^a |
| 0,5 | 42.26±0.00 ^c | 2.96±0.02 ^a | 683.64±22.02 ^d | 0.92±0.01 ^{ab} | 0.65±0.01 ^b |
| 1 | 42.18±0.00 ^{bc} | 3.40±0.02 ^c | 557.14±10.39 ^c | 0.93±0.02 ^{ab} | 0.66±0.01 ^{bc} |
| 1,5 | 42.05±0.00 ^b | 3.55±0.03 ^d | 451.13±5.85 ^b | 0.93±0.01 ^{bc} | 0.66±0.02 ^{bc} |
| 2 | 41.79±0.00 ^a | 3.61±0.02 ^e | 326.93±27.12 ^a | 0.95±0.01 ^c | 0.67±0.02 ^c |

*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 ^{ab} | 3.76±1.31 ^a | 3.83±1.27 ^a |
| 0.5 | 4.55±1.49 ^a | 4.41±1.45 ^b | 4.34±1.51 ^b |
| 1 | 5.00±1.36 ^b | 4.45±1.58 ^b | 4.45±1.10 ^b |
| 1.5 | 5.03±1.26 ^b | 5.20±1.24 ^c | 5.00±1.38 ^c |
| 2 | 5.52±1.16 ^c | 5.24±1.23 ^c | 5.02±1.29 ^c |

*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 cm³/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 (cm^3/g) = volume (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, Na^+ will be released and replaced with 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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|--------------------------|--------------------------------------|---------------------------|-------------------------|-------------------------|
| 0 | 42.27±0.00 ^c | 3.29±0.01 ^b | 724.86±5.99 ^c | 0.92±0.00 ^a | 0.64±0.03 ^a |
| 0.5 | 42.26±0.00 ^c | 2.96±0.02 ^a | 683.64±22.02 ^d | 0.92±0.01 ^{ab} | 0.65±0.01 ^b |
| 1 | 42.18±0.00 ^{bc} | 3.40±0.02 ^c | 557.14±10.39 ^c | 0.93±0.02 ^{ab} | 0.66±0.01 ^{bc} |
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| 2 | 41.79±0.00 ^a | 3.61±0.02 ^e | 326.93±27.12 ^a | 0.95±0.01 ^c | 0.67±0.02 ^c |

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 CO₂ gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of

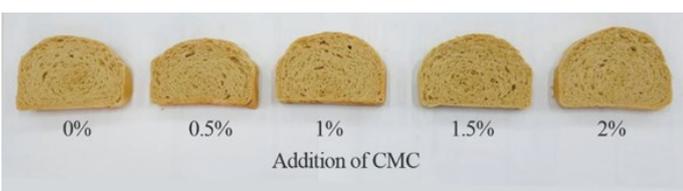


Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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 ^{ab} | 3.76±1.31 ^a | 3.83±1.27 ^a |
| 0.5 | 4.55±1.49 ^a | 4.41±1.45 ^b | 4.34±1.51 ^b |
| 1 | 5.00±1.36 ^b | 4.45±1.58 ^b | 4.45±1.10 ^b |
| 1.5 | 5.03±1.26 ^b | 5.20±1.24 ^c | 5.00±1.38 ^c |
| 2 | 5.52±1.16 ^c | 5.24±1.23 ^c | 5.02±1.29 ^c |

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 cm³/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 (cm^3/g) = volume (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, Na^+ will be released and replaced with 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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|--------------------------|--------------------------------------|---------------------------|-------------------------|-------------------------|
| 0 | 42.27±0.00 ^c | 3.29±0.01 ^b | 724.86±5.99 ^c | 0.92±0.00 ^a | 0.64±0.03 ^a |
| 0.5 | 42.26±0.00 ^c | 2.96±0.02 ^a | 683.64±22.02 ^d | 0.92±0.01 ^{ab} | 0.65±0.01 ^b |
| 1 | 42.18±0.00 ^{bc} | 3.40±0.02 ^c | 557.14±10.39 ^c | 0.93±0.02 ^{ab} | 0.66±0.01 ^{bc} |
| 1.5 | 42.05±0.00 ^b | 3.55±0.03 ^d | 451.13±5.85 ^b | 0.93±0.01 ^{bc} | 0.66±0.02 ^{bc} |
| 2 | 41.79±0.00 ^a | 3.61±0.02 ^e | 326.93±27.12 ^a | 0.95±0.01 ^c | 0.67±0.02 ^c |

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 CO₂ 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 ^{ab} | 3.76±1.31 ^a | 3.83±1.27 ^a |
| 0.5 | 4.55±1.49 ^a | 4.41±1.45 ^b | 4.34±1.51 ^b |
| 1 | 5.00±1.36 ^b | 4.45±1.58 ^b | 4.45±1.10 ^b |
| 1.5 | 5.03±1.26 ^b | 5.20±1.24 ^c | 5.00±1.38 ^c |
| 2 | 5.52±1.16 ^c | 5.24±1.23 ^c | 5.02±1.29 ^c |

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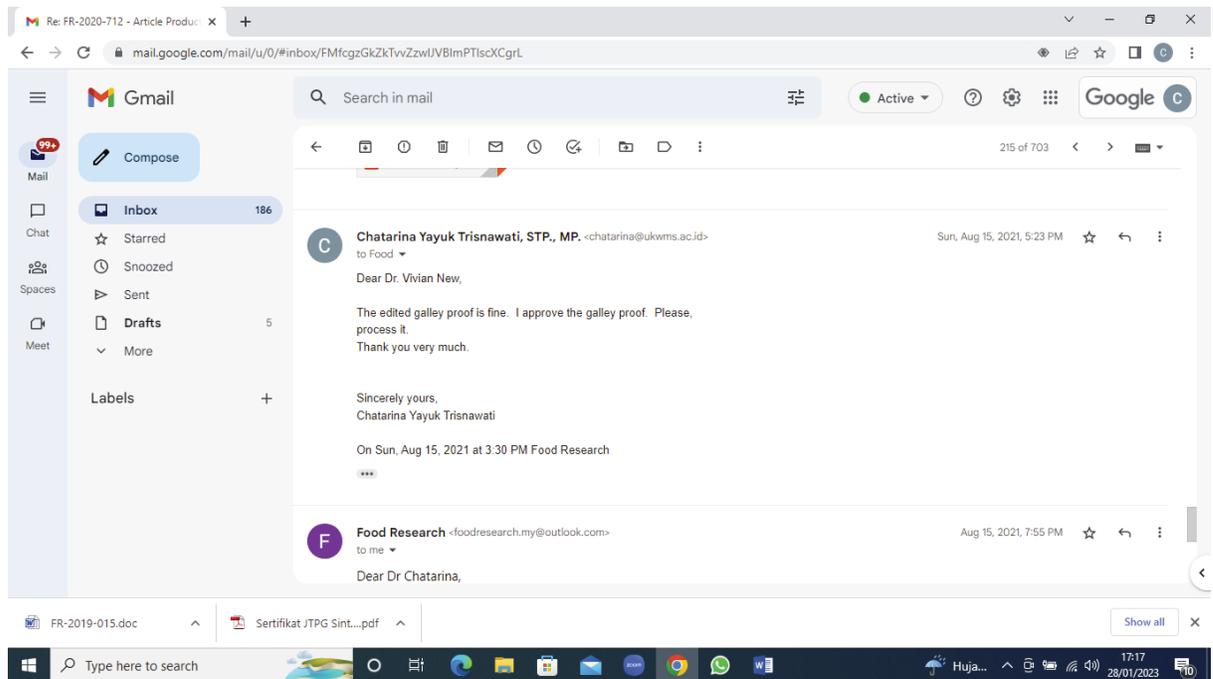
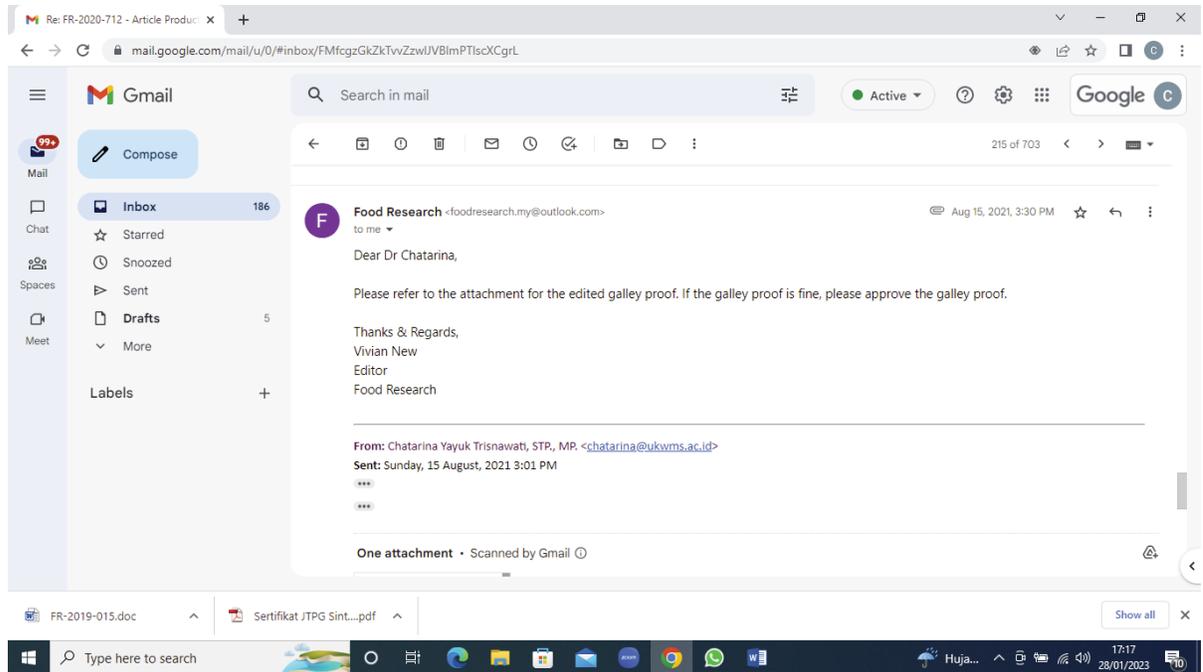
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Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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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 cm³/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 (cm^3/g) = volume (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, Na^+ will be released and replaced with 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 ³ /g) | Hardness (g) | Springiness (mm) | Cohesiveness |
|-----------------------|--------------------------|--------------------------------------|---------------------------|-------------------------|-------------------------|
| 0 | 42.27±0.00 ^c | 3.29±0.01 ^b | 724.86±5.99 ^c | 0.92±0.00 ^a | 0.64±0.03 ^a |
| 0.5 | 42.26±0.00 ^c | 2.96±0.02 ^a | 683.64±22.02 ^d | 0.92±0.01 ^{ab} | 0.65±0.01 ^b |
| 1 | 42.18±0.00 ^{bc} | 3.40±0.02 ^c | 557.14±10.39 ^c | 0.93±0.02 ^{ab} | 0.66±0.01 ^{bc} |
| 1.5 | 42.05±0.00 ^b | 3.55±0.03 ^d | 451.13±5.85 ^b | 0.93±0.01 ^{bc} | 0.66±0.02 ^{bc} |
| 2 | 41.79±0.00 ^a | 3.61±0.02 ^e | 326.93±27.12 ^a | 0.95±0.01 ^c | 0.67±0.02 ^c |

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 CO₂ gas at high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of

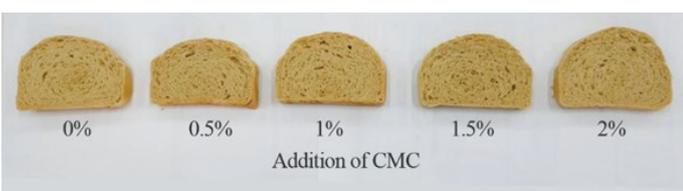


Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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 ^{ab} | 3.76±1.31 ^a | 3.83±1.27 ^a |
| 0.5 | 4.55±1.49 ^a | 4.41±1.45 ^b | 4.34±1.51 ^b |
| 1 | 5.00±1.36 ^b | 4.45±1.58 ^b | 4.45±1.10 ^b |
| 1.5 | 5.03±1.26 ^b | 5.20±1.24 ^c | 5.00±1.38 ^c |
| 2 | 5.52±1.16 ^c | 5.24±1.23 ^c | 5.02±1.29 ^c |

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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