BUKTI KORESPONDENSI

Judul Artikel : Effect of *Carboxymethylcellulose* on the Physicochemical and Sensory Properties of Bread Enriched with Rice Bran

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

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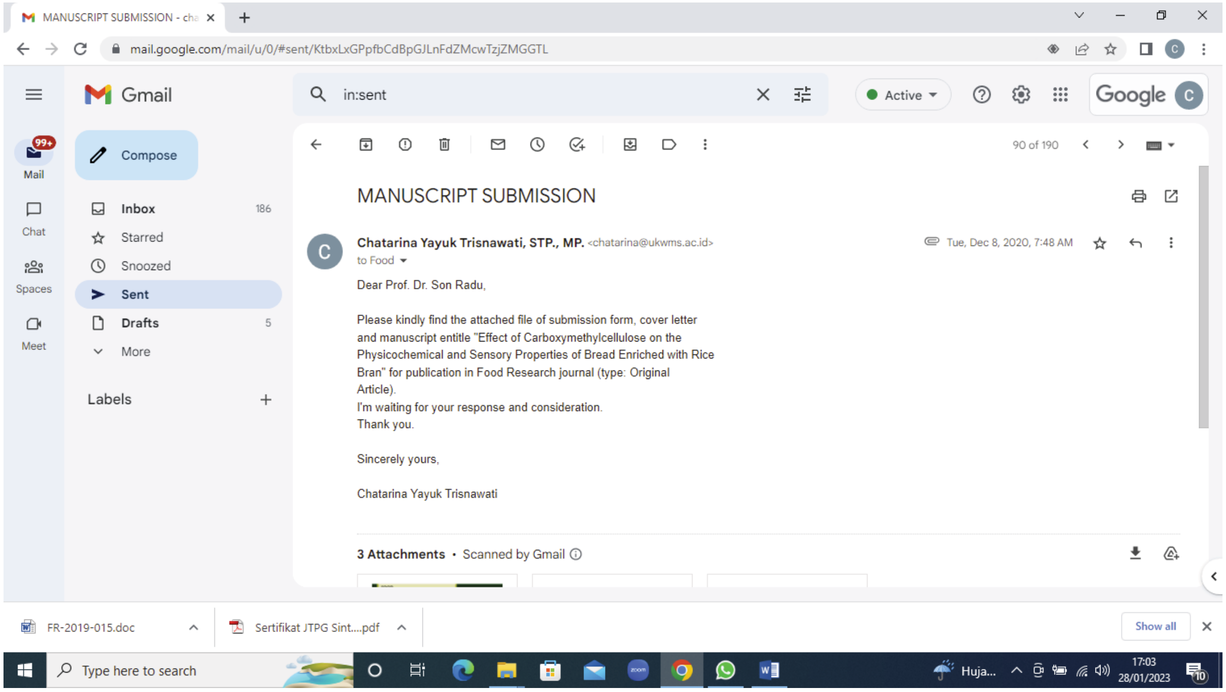

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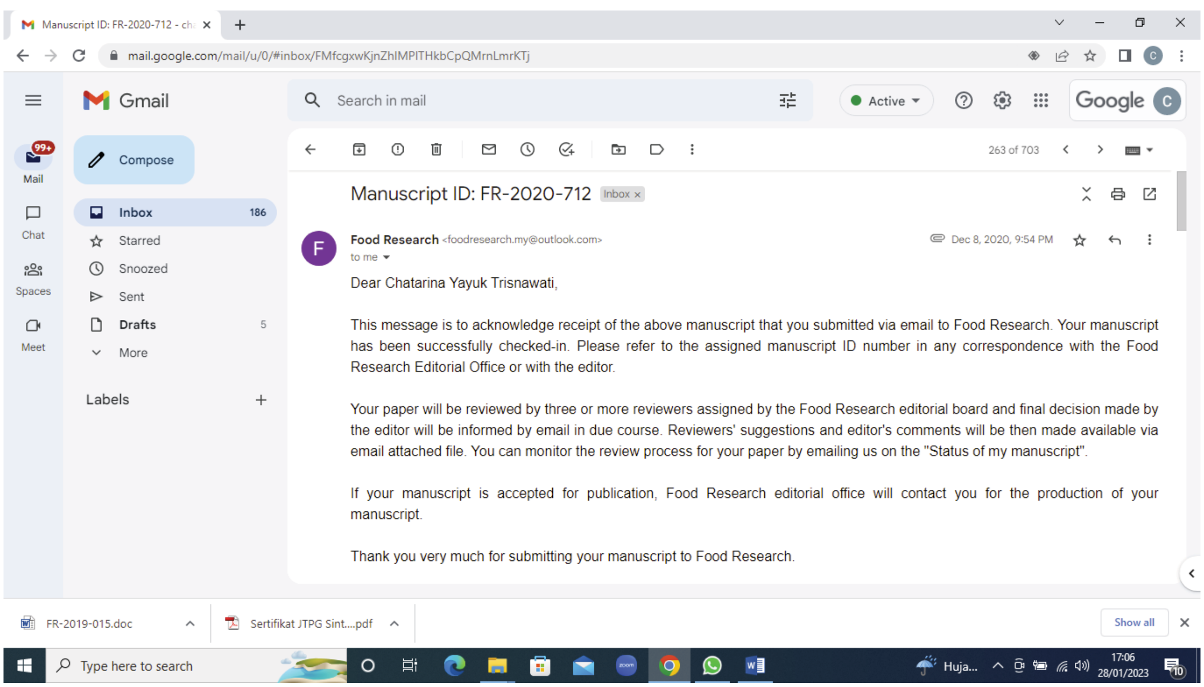

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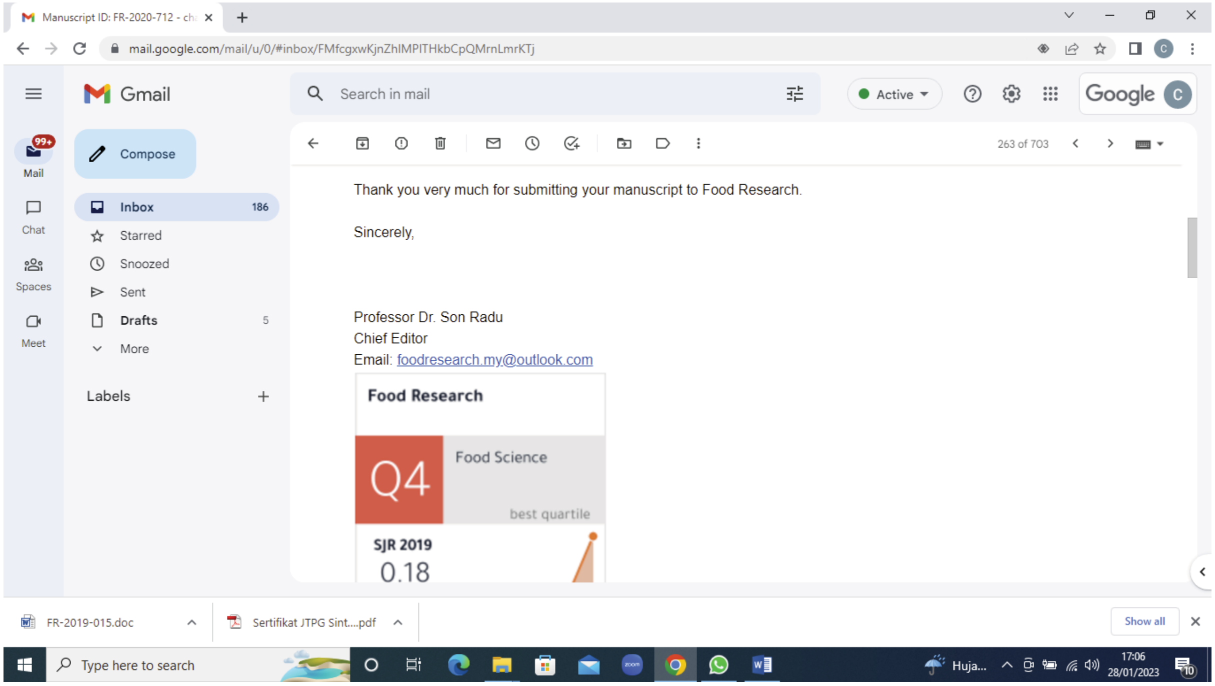
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Effect of *Carboxymethylcellulose* on the Physicochemical and Sensory Properties of Bread Enriched with Rice Bran

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

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Abstract

Bread enriched with rice bran is one of the innovation product of bread. Addition of rice bran aims to increase the fibre content in bread so it can be developed as functional bread. Addition of 10% rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran to be harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethylcellulose (CMC). The aim of the research was to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was 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 determined based on sensory test results with the spiderweb method was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%; specific volume 3.61 cm^3/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, carboxymethylcellulose, physicochemical properties, sensory properties

1. Introduction

Bread is one of the oldest and most popular source 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.

Ameh, Gernah, and Igbabul (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 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.

Rice bran is a by-product of the process of milling grain into rice. The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and rich in fibre. The reduction of gluten and increased fibre in the manufacture of bread resulting bread with tougher texture and reduced expansion volume. The tougher texture and reduced expansion volume in making rice bran bread can be prevail over by adding hydrocolloid in the form of Carboxymethylcellulose (CMC). 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 with the aim of retaining 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.

The aim of this research was to study the effect of CMC concentrations of 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 Carboxymethylcelullose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from local market.

2.2 Bread Formulating 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 bread pan and cooled down at room temperature for 60 minutes.

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, in order to obtain 25 experimental units. Data were analysed 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 test, then the test was continued with the Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$ to find out which treatment level gives the significant difference results.

2.4 Evaluation of bread enriched with rice bran characteristic

The parameters examined in this study include moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content were measured with thermo gravimetric 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 dough (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 panelists participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders. Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread samples were labeled with three-digit codes and randomly presented to avoid 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 ease to bite, softness, and moistness of rice bran bread with differences CMC concentrations can be seen in Table 2.

3.1 Moisture Content

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 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 Sindhu 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. It can be observed in Table 1 that the higher addition of CMC in bread enriched with rice bran resulting lower moisture content. 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.

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 the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher gas retention. During baking, there is expansion of CO_2 gas by 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 increase addition of CMC. The addition of CMC resulted in decreased hardness of bread because the hydrocolloid was able to provide elastic properties so that the force required for crumb deformation was smaller. 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. After baking the bread will have a firm texture and dense pores. The addition of CMC can increase the viscoelasticity of bread dough so that the texture of bread becomes easier to deform.

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 will resulted more elastic bread. According to Grubber (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 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. The results of the springiness test of bread enriched with rice bran can be observed in Table 1.

3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases with the increase 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 Ease to bite

The preference for ease to bite has 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 bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.The results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2.

3.7 Softness

The results of bread enriched with rice bran softness can be observed in Table 2. The addition of CMC affects on 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, it will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer. The value of the softness of bread enriched with rice bran that is preferred by the panellists is at a CMC concentration of 1.5-2% with an average sensory test value of 5.20-5.24 (slightly preferred).

3.8 Moistness

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 mouthfeel of bakery products. Moistness of bread has 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 bread is consumed. The results sensory test value (moistness) of bread enriched with rice bran bread can be observed in Table 2.

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 increase preference in ease to bite, softness and moistness.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

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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 ± 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 (α = 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^{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 ± 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 (α = 0.05).

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

2.

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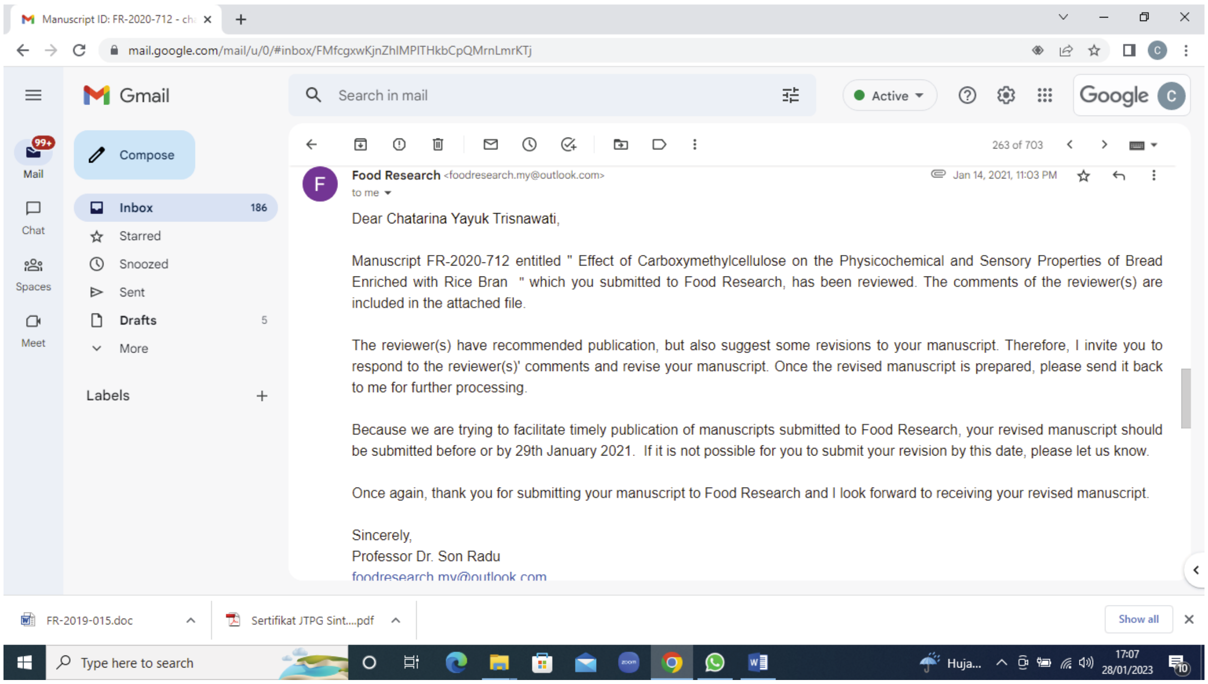
(14 Januari 2021)



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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 with the aim of retaining 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.

The aim of this research was to study the effect of CMC concentrations of 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 Carboxymethylcelullose), full cream milk powder, mineral water, iodized salt, sugar, margarine, instant yeast, and bread improver were obtained from local market.

2.2 Bread Formulating 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 bread pan and cooled down at room temperature for 60 minutes.

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, in order to obtain 25 experimental units. Data were analysed 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 test, then the test was continued with the Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$ to find out which treatment level gives the significant difference results.

2.4 Evaluation of bread enriched with rice bran characteristic

The parameters examined in this study include moisture content, specific volume, and texture profile including hardness, springiness, cohesiveness and sensory evaluation. Moisture content were measured with thermo gravimetric 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 dough (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 panelists participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders. Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread samples were labeled with three-digit codes and randomly presented to avoid 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 ease to bite, softness, and moistness of rice bran bread with differences CMC concentrations can be seen in Table 2.

3.1 Moisture Content

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 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 Sindhu 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. It can be observed in Table 1 that the higher addition of CMC in bread enriched with rice bran resulting lower moisture content. 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.

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 the results of research by Sidhu and Bawa (2000), the more CMC is added, the higher gas retention. During baking, there is expansion of CO_2 gas by high temperatures, but because of the high gas retention, the shape of the bread can be maintained and the volume of bread is higher.

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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 will resulted more elastic bread. According to Grubber (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 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. The results of the springiness test of bread enriched with rice bran can be observed in Table 1. Need to interpret further the results here with discussion???

3.5 Cohesiveness

Table 1 shows that the cohesiveness value increases with the increase 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 Ease to bite

The preference for ease to bite has 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 bread. The CMC concentration of 2% resulted in the highest bite ability value, which was 5.52 which meant that it was slightly preferred.The results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2.(This sentence is hanging as not clear whats next???)

3.7 Softness

The results of bread enriched with rice bran softness can be observed in Table 2. The addition of CMC affects on 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, it will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer. The value of the softness of bread enriched with rice bran that is preferred by the panellists is at a CMC concentration of 1.5-2% with an average sensory test value of 5.20-5.24 (slightly preferred).(again results statement after discussion?)

3.8 Moistness

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 mouthfeel of bakery products. Moistness of bread has 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 bread is consumed. The results sensory test value (moistness) of bread enriched with rice bran bread can be observed in Table 2. (again results statement after discussion?)

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 increase preference in ease to bite, softness and moistness.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

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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 ± 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 ($\alpha = 0.05$).

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 ± 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 ($\alpha = 0.05$).

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

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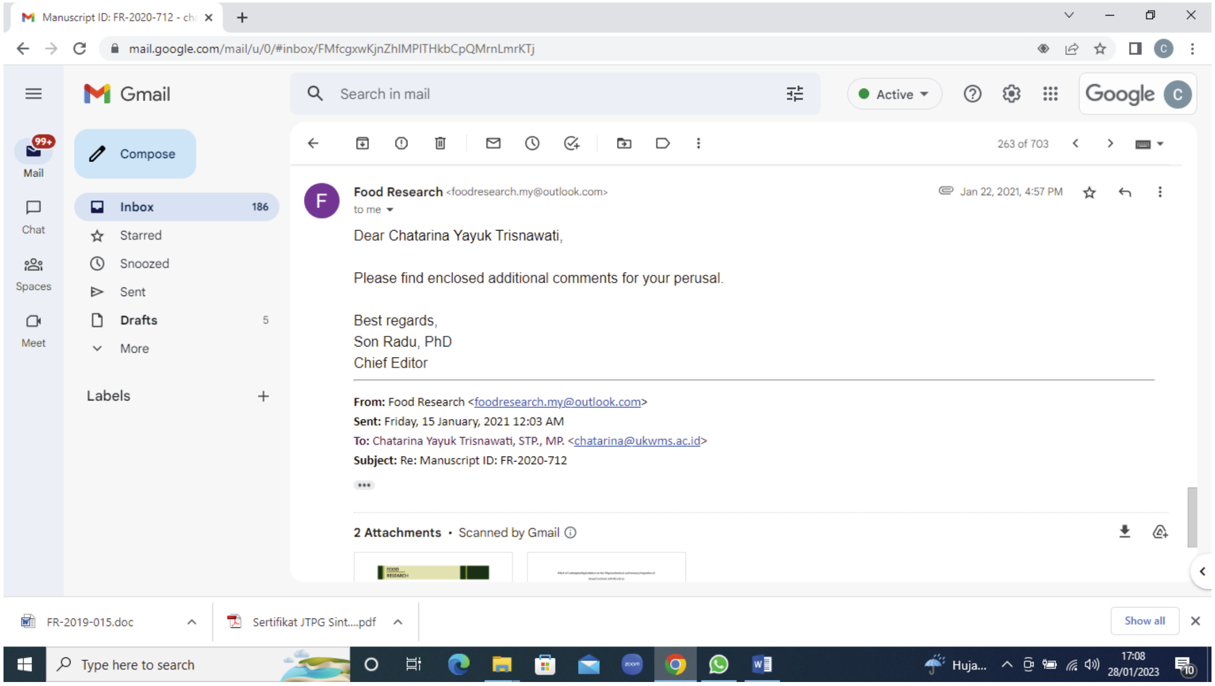
Bukti konfirmasi review dan hasil review dari Reviewer II

(22 Januari 2021)



Manuscript ID: FR-2020-712

Food Research <foodresearch.my@outlook.com>
to me
Jan 22, 2021, 4:57 PM

Dear Chatarina Yayuk Trisnawati,

Please find enclosed additional comments for your perusal.

Best regards,
Son Radu, PhD
Chief Editor

From: Food Research <foodresearch.my@outlook.com>
Sent: Friday, 15 January, 2021 12:03 AM
To: Chatarina Yayuk Trisnawati, STP., MP. <chatarina@ukwms.ac.id>
Subject: Re: Manuscript ID: FR-2020-712

2 Attachments • Scanned by Gmail

Effect of *Carboxymethylcellulose* on the Physicochemical and Sensory Properties of Bread Enriched with Rice Bran

Abstract

Bread enriched with rice bran is one of the ~~innovation product~~innovative products of bread. ~~Addition of rice bran aims to increase the fibre content in bread so it can be developed as functional bread~~. The ~~A~~addition of 10% rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran ~~to be~~being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethylcellulose (CMC). ~~The aim of the research was~~the reseach 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 determined based on sensory test results with the spiderweb method was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%; specific volume 3.61 cm^3/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, carboxymethylcellulose, physicochemical properties, sensory properties

1. Introduction

Bread is one of the oldest and most popular sources of processed food products. Bread is 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.

Ameh, Gernah, and Igbabul (2013) reported the results of the analysis of the crude ~~fibre~~fiber 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 pane~~l~~lists.

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

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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~~, in order to obtain 25 experimental units~~. Data were analy~~s~~zed statistically using ANOVA (Analysis of Variance) at α = 5% to determine whether the treatment had a significant effect. If there is a significant effect on the results of the ANOVA test, then the test was continued with the Duncan's Multiple Range Test (DMRT) at α = 5% to find out which treatment level gives the significantly ~~difference~~different results.

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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 will resulted in more elastic bread. According to Grubber (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 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. The results of the springiness test of bread enriched with rice bran can be observed in Table 1.

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 Ease to bite

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. The results of the easiness of the bite of bread enriched with rice bran can be seen in Table 2.

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3.7 Softness

The results of bread enriched with rice bran softness can be observed in Table 2. The addition of CMC affects ~~on~~ 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). Panel~~l~~ists prefer white bread with its characteristic thin and soft pore walls. The higher CMC concentration~~, it~~ will produce bread with thinner and larger pore walls so that the resulting bread structure becomes softer. The value of the softness of bread enriched with rice bran that is preferred by the ~~panellists~~panelists is at a CMC concentration of 1.5-2% with an average sensory test value of 5.20-5.24 (slightly preferred).

3.8 Moistness

The ~~panellists~~panelists 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. The results sensory test value (moistness) of bread enriched with rice bran bread can be observed in Table 2.

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 increase preference in ease to bite, softness and moistness.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

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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 ± 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 (α = 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^{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 ± 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 (α = 0.05).

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

4.

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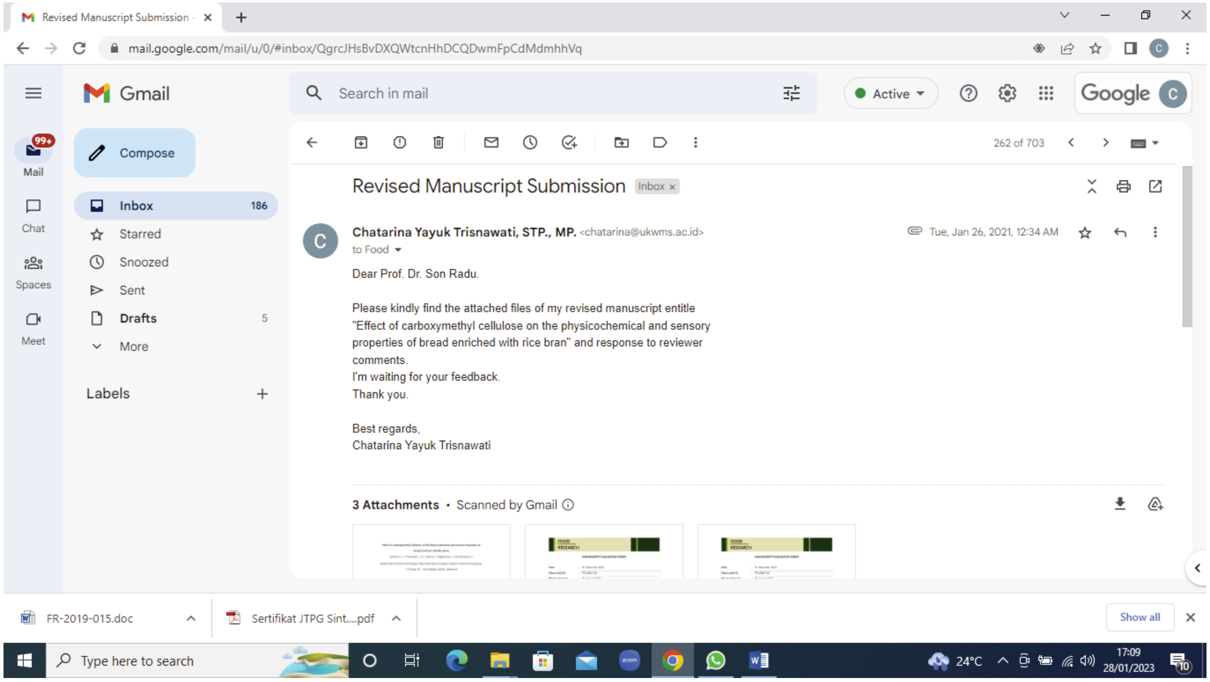


Revised Manuscript Submission

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

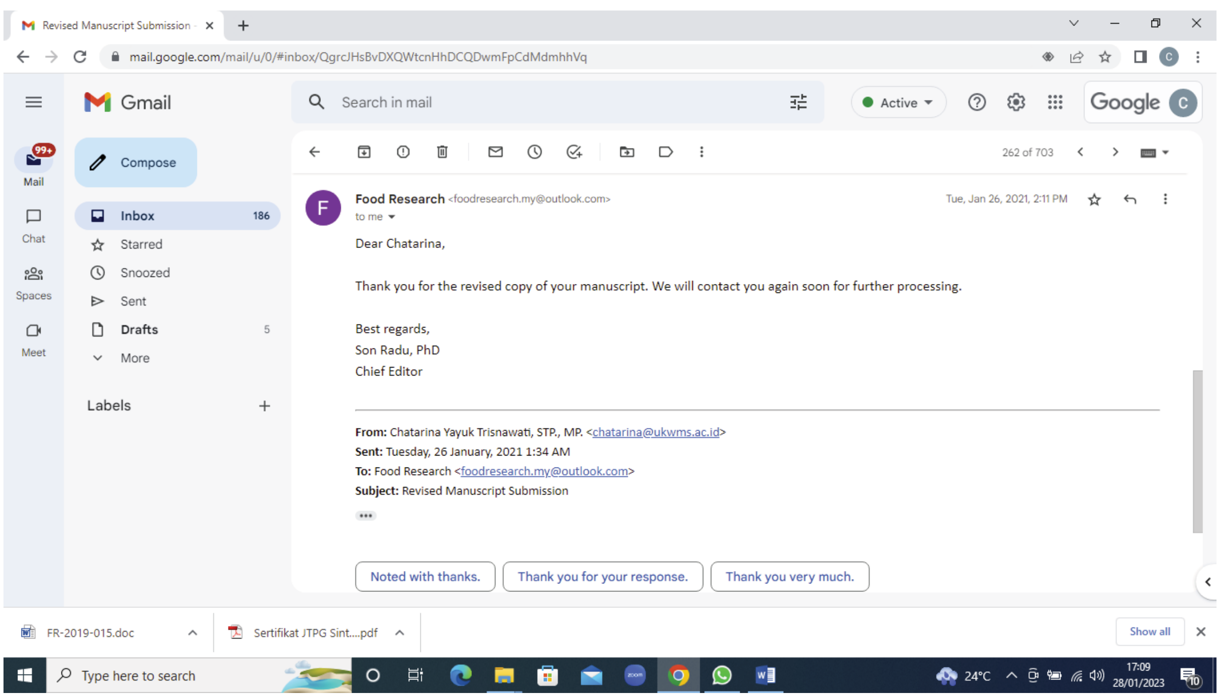
Tue, Jan 26, 2021, 12:34 AM

Dear Prof. Dr. Son Radu.

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

Best regards,
Chatarina Yayuk Trisnawati

3 Attachments • Scanned by Gmail



Food Research <foodresearch.my@outlook.com>
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Thank you for the revised copy of your manuscript. We will contact you again soon for further processing.

Best regards,
Son Radu, PhD
Chief Editor

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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% rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran; increased specific volume; decreased hardness; increased springiness; increased cohesiveness; increased preference sensory properties ease to bite; softness; and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%; specific volume 3.61 cm^3/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 source 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 bakery product. Rice bran is a by-product of the process of milling grain into the rice and has developed into functional food. Rice bran contains a number of phenolic compounds, rich in dietary fiber, vitamins, minerals and essential amino acids (Henderson *et al*., 2012).

Sairam, Khrisna, and Urooj (2011) have added rice bran as much as 5% and 10% into bread and produced bread with acceptable physicochemical properties. Ameh, Gernah, and Igbabul (2013) reported the results of the analysis of the crude fiber 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 panelists.

The addition of rice bran to making bread affects the characteristics of the bread because the rice bran does not contain gluten and rich in fiber. The reduction of gluten and increased fiber in the manufacture of bread resulting 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 Carboxymethylcelullose), 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 minutes.

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 α = 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 α = 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: 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 panelists participated in the sensory evaluation. Panelists had no previous or present taste or smell disorders. Each panelist received 5 pieces of bread enriched with rice bran samples with a size of 2x2x1 cm, bread samples were labeled 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 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 texture and porous 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 result in 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 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). Panelists 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 moistness of bread enriched with rice bran can be observed in Table 2. The panelists 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.

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 increase preference in ease to bite, softness and moistness. The use of CMC improve 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.

Acknowledgments

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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 ± 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 ($\alpha = 0.05$).

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 ± 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 ($\alpha = 0.05$).

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

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6. Relevance to the Journal	√				

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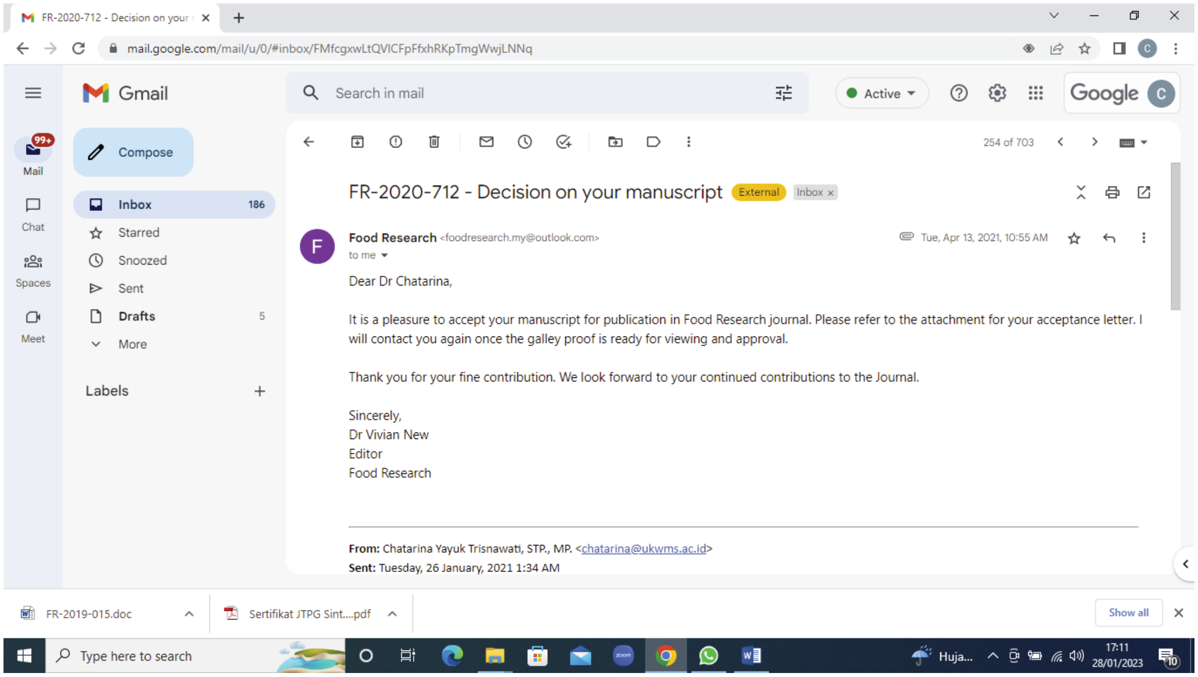

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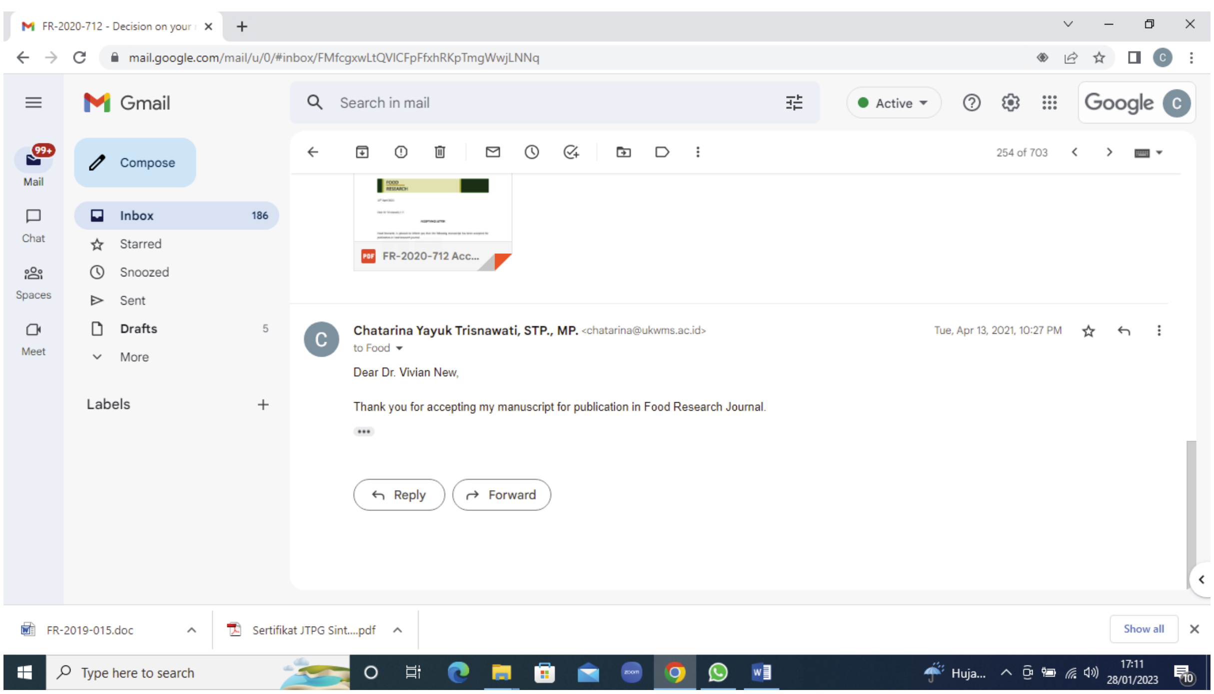

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13th April 2021

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Food Research, is pleased to inform you that the following manuscript has been accepted for publication in Food Research journal.

Manuscript Title	:	Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran
Authors	:	Harsono, C., Trisnawati, C.Y., Srianta, I., Nugerahani, I. and Marsono, Y.

We thank you for your fine contribution to the Food Research journal and encourage you to submit other articles to the Journal.

Yours sincerely,

Professor Dr. Son Radu
Chief Editor
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6.

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(10 Agustus 2021)

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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., Srianta, 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 cm^3/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 α = 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 α = 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: 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 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.

Acknowledgements

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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 ± 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 (α = 0.05).

Commented [VN1]: There are no standard deviations after the means. Please check.

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 ± 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 (α = 0.05).

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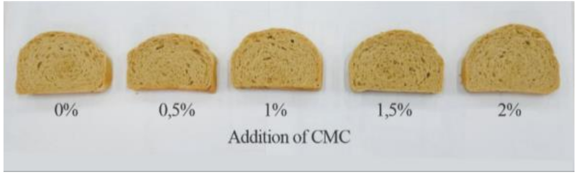

Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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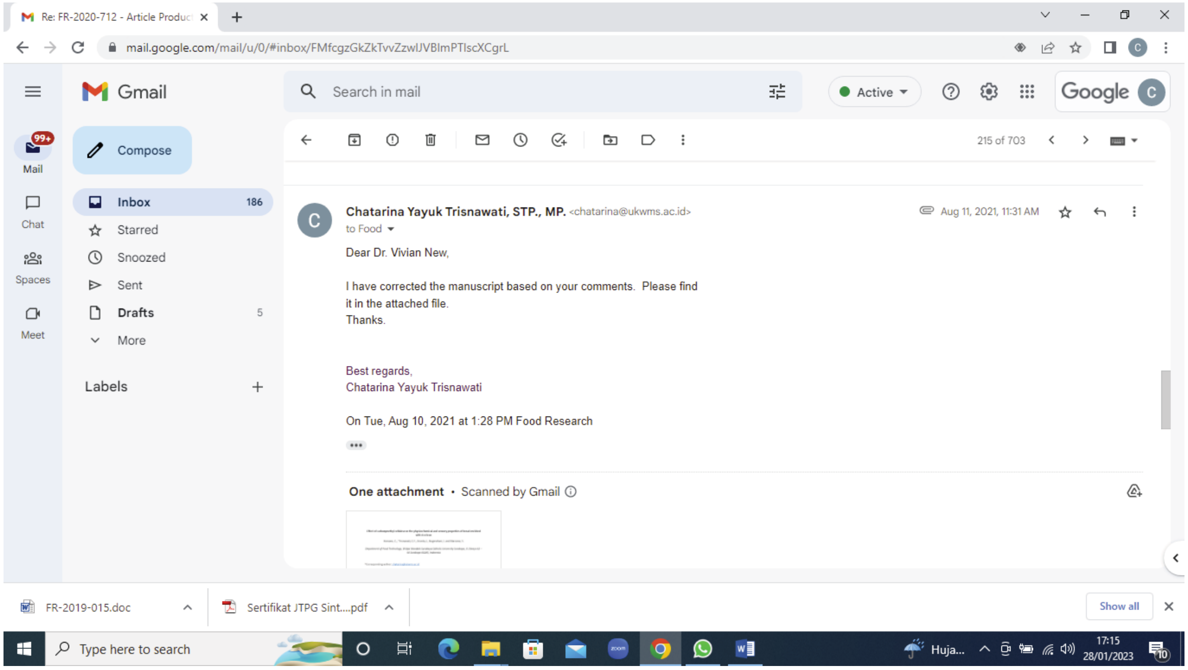

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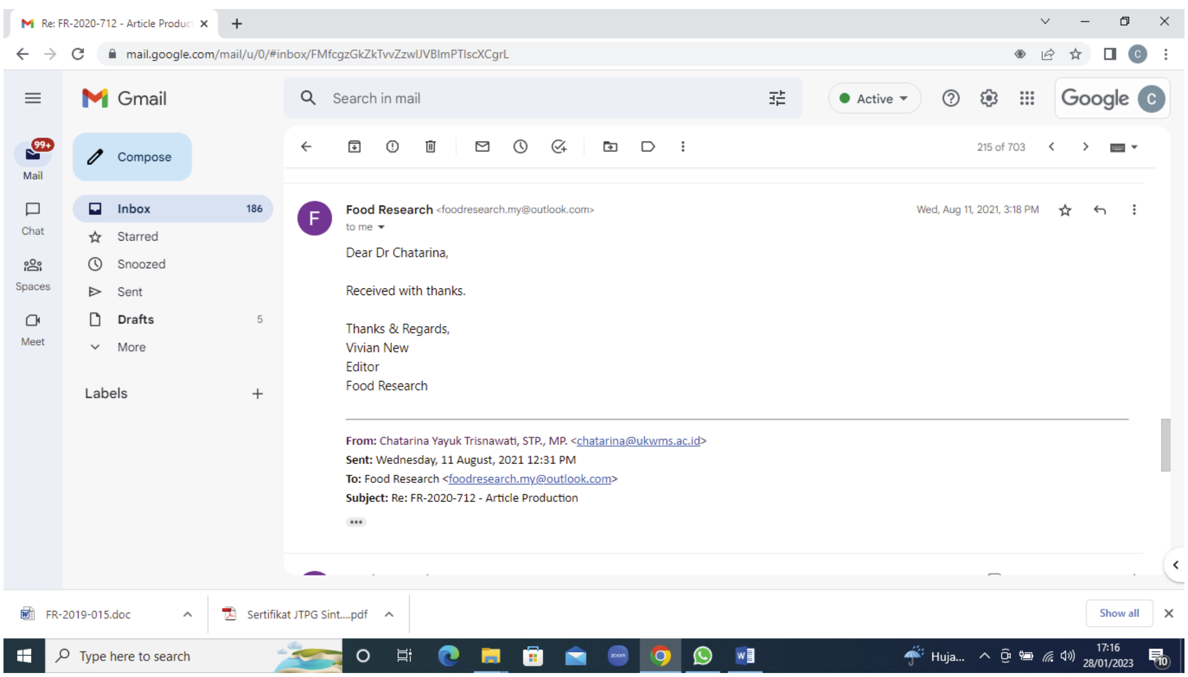

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Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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Abstract

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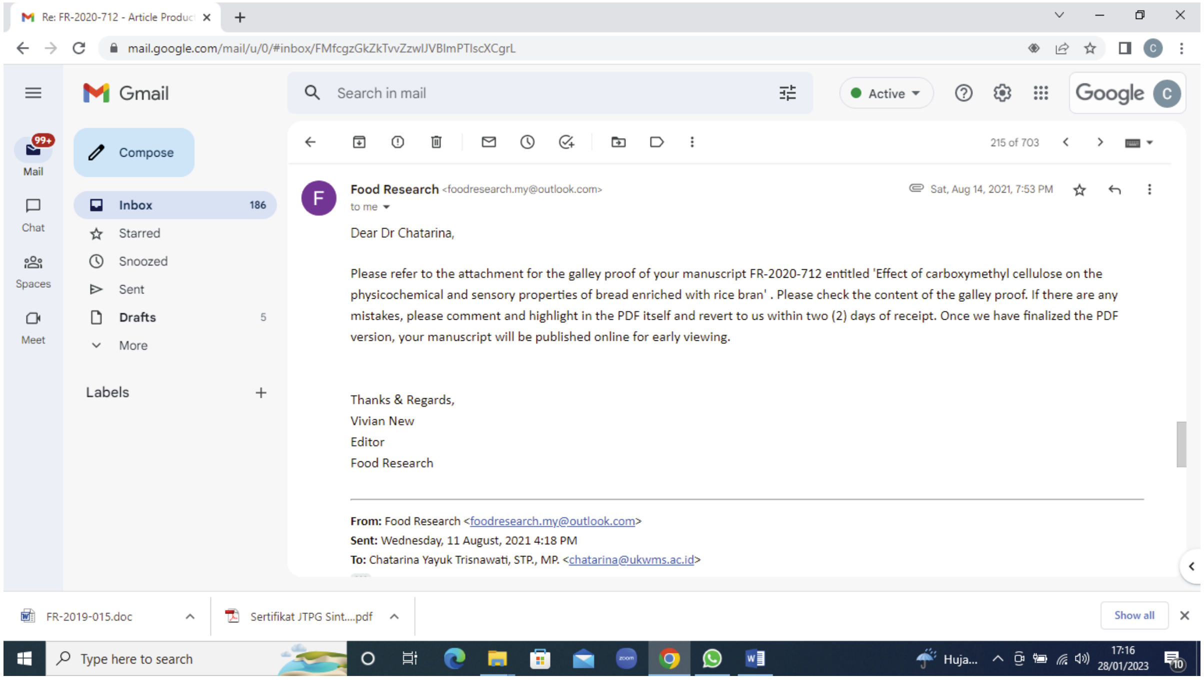

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Effect of carboxymethyl cellulose on the physicochemical and sensory properties of bread enriched with rice bran

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Abstract

Bread enriched with rice bran is one of the innovative products of bread. The addition of 10% of rice bran into bread will reduce the specific volume of bread and result in the texture of bread enriched with rice bran being harder. Texture and volume development problems in the making of bread enriched with rice bran can be improved by adding Carboxymethyl Cellulose (CMC). The research aimed to observe the effect of CMC concentration on the physicochemical and sensory properties of bread enriched with rice bran. The research design was a Randomized Block Design consisting of one factor which was the CMC concentration with five levels, 0%, 0.5%, 1%, 1.5%, and 2% with five replications. The results showed that increasing CMC concentration decreased moisture content in bread enriched with rice bran, increased specific volume, decreased hardness, increased springiness, increased cohesiveness, increased preference sensory properties ease to bite, softness, and moistness. The best treatment was 2% CMC addition. Bread enriched with rice bran with 2% CMC concentration has moisture content 41.79%, specific volume 3.61 cm^3/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 2×2×1 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[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 presented as mean±SD (n = 3 for each group). Values with the same superscript within the column are not significantly ($p>0.05$) different evaluated by ANOVA followed by DMRT test ($\alpha = 0.05$).

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

3.2 Specific volume

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

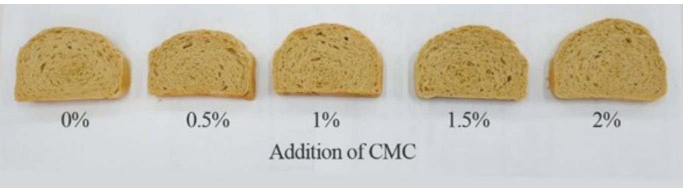

Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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

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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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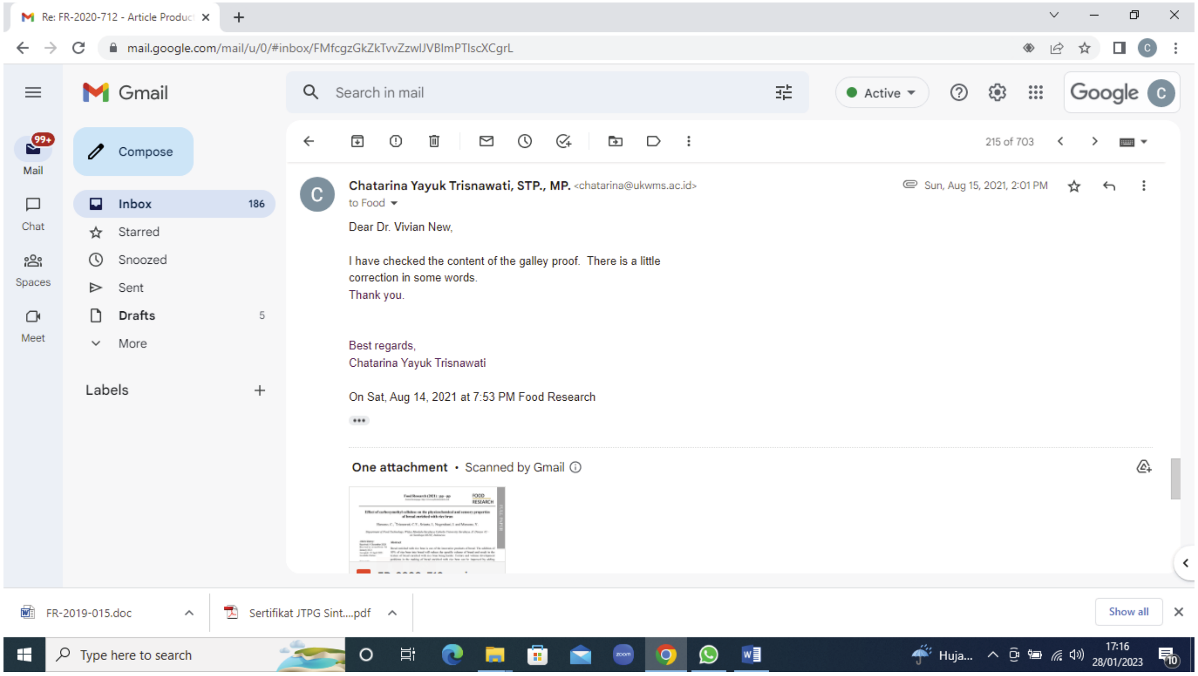
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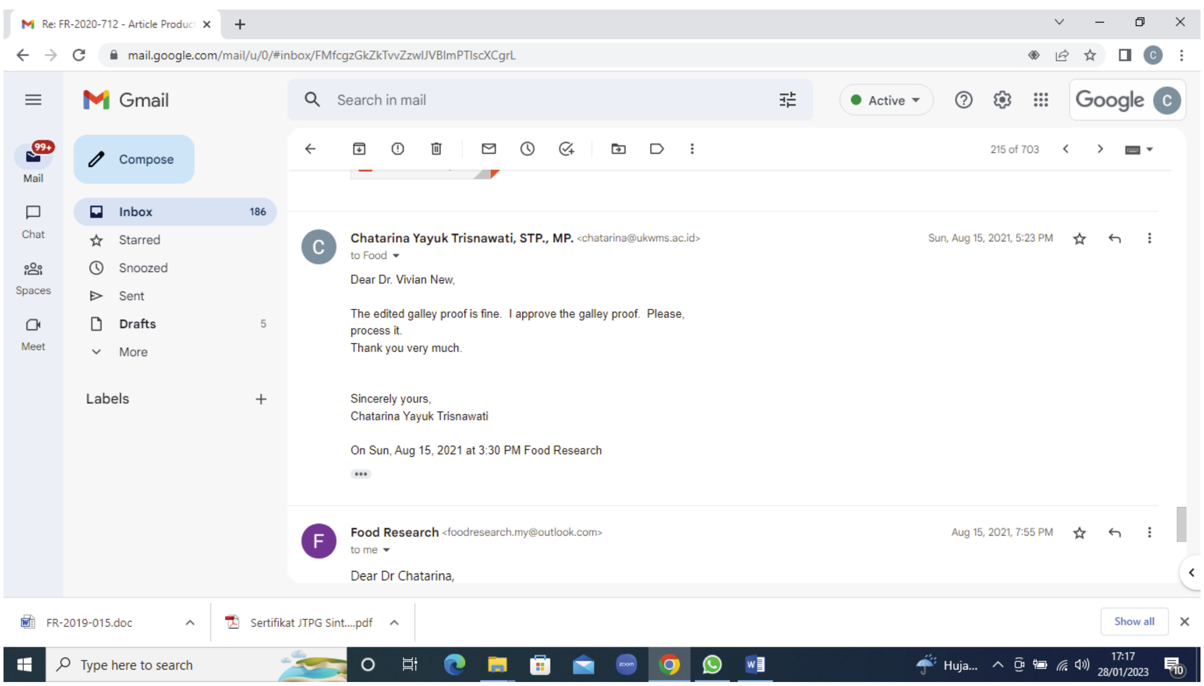
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FULL PAPER

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

Harsono, C., *Trisnawati, C.Y., Srianta, 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 cm^3/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 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: 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 2×2×1 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^{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 presented as mean±SD (n = 3 for each group). Values with the same superscript within the column are not significantly ($p>0.05$) different evaluated by ANOVA followed by DMRT test ($\alpha = 0.05$).

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

3.2 Specific volume

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

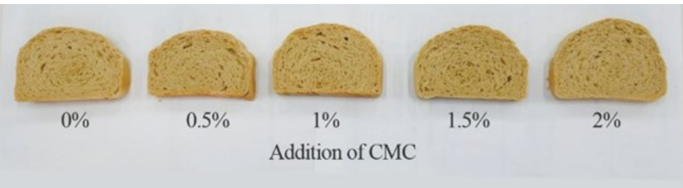

Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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 (α = 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.

Acknowledgements

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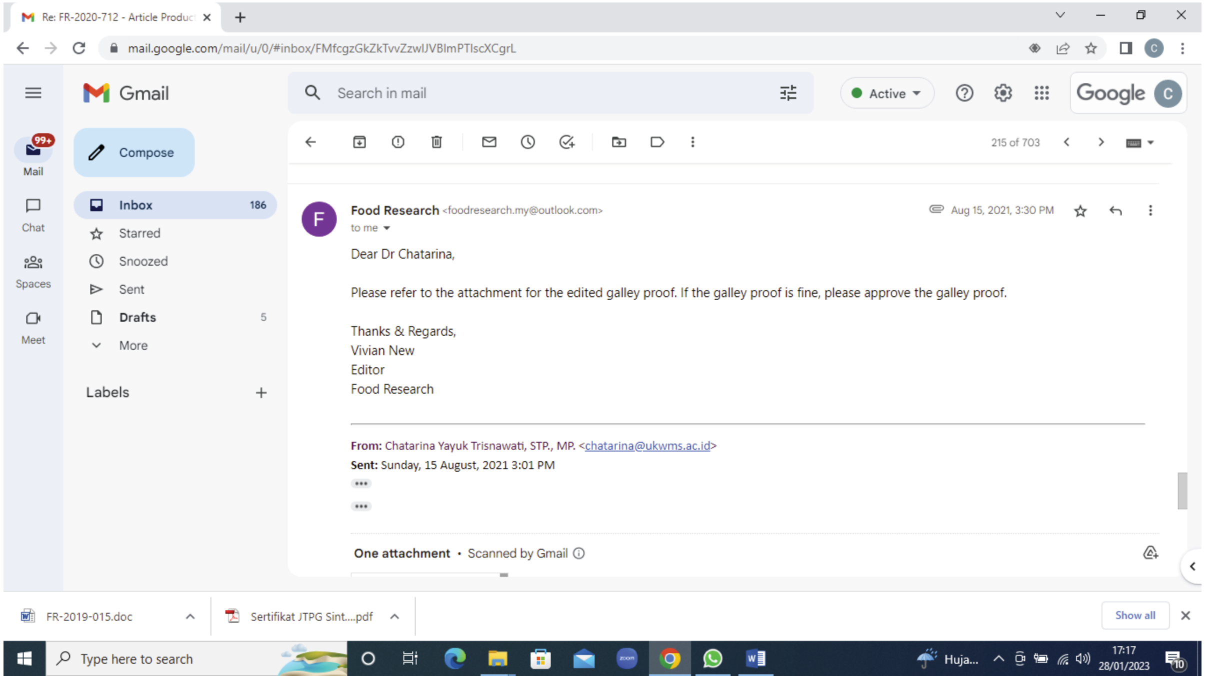
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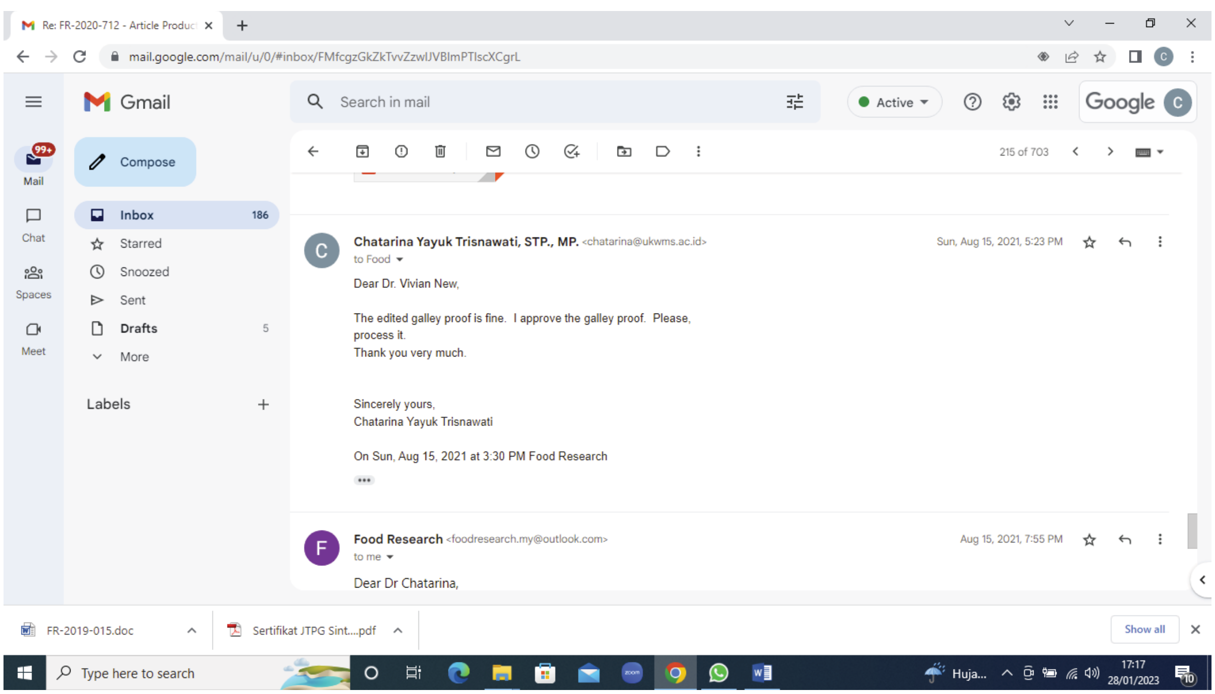
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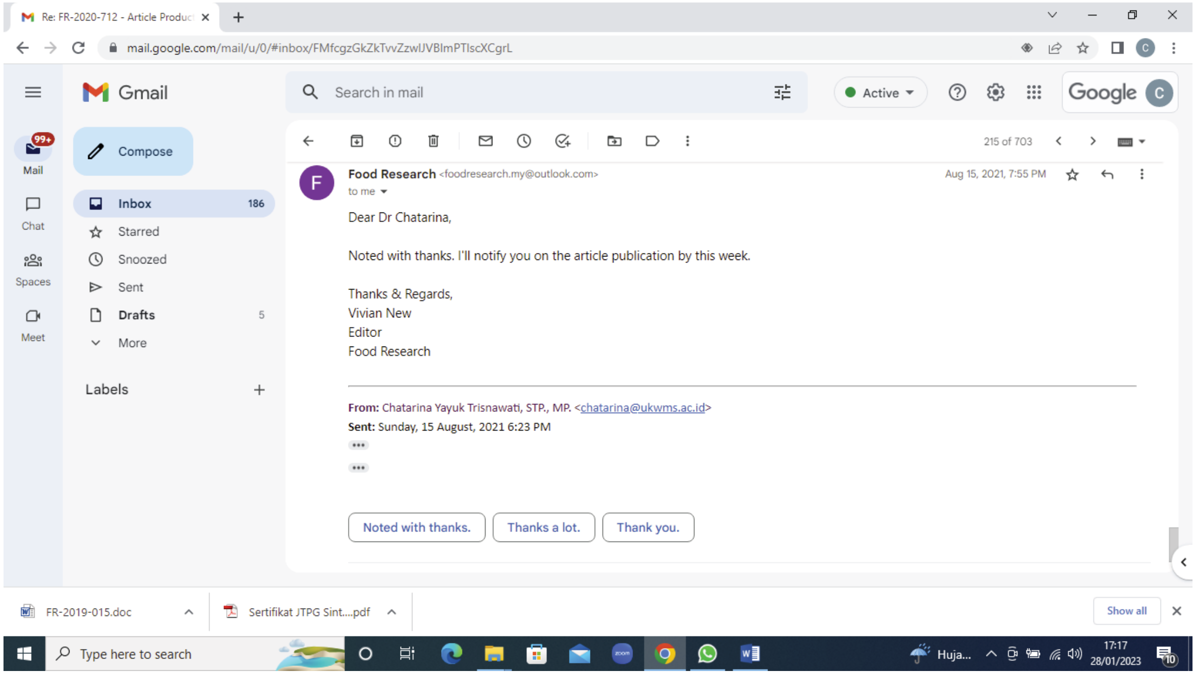

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FULL PAPER

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

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Abstract

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

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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 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 (α = 0.05).

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

3.2 Specific volume

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

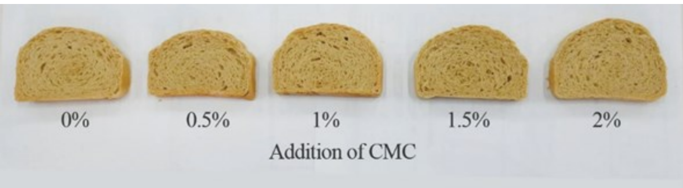

Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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

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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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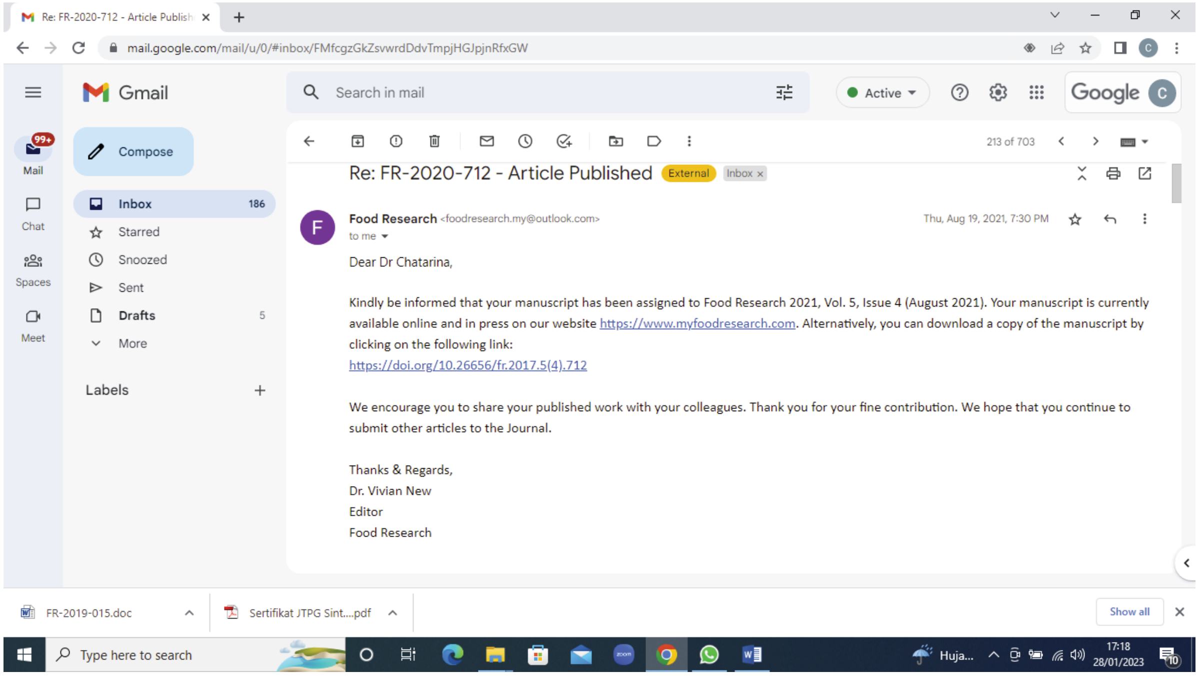

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