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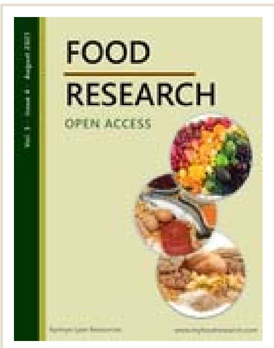

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Volume 5, Issue 4

August 2021

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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 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.

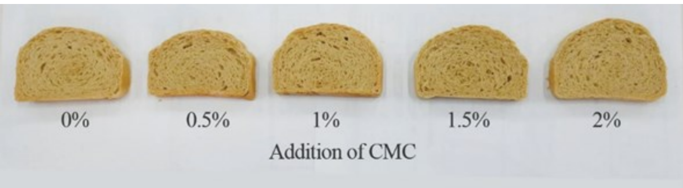

Figure 1. Cross section of bread enriched with rice bran with different addition of CMC

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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