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Physical and Sensory Characteristics of Bread from Composite Wheat and Cassava Flours with Optimum Fermentation and Proportional Water Volume

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Abstract

The purpose of the research was to evaluate the physical characteristics and sensory of bread from the composite flours of wheat and cassava with optimum fermentation and the proportional water volume. The study was conducted by optimizing the fermentation of the dough and using the proportional water volume. The research was conducted with 4 treatments of composite wheat flour and cassava flour, which were 100: 0, 90:10, 80:20, and 70:30. The bread was then tested for the expansion, hardness, elasticity and sensory acceptance. The results indicated that the higher portion of cassava flour, the lower the expansion of bread. The highest expansion of bread was given by the 100: 0, which was 64.9 mm for 55 min fermentation. The highest hardness of bread was displayed by the 70:30, which was 3482.7 g for 75 min fermentation and 3372 g for 85 min fermentation, whereas, the lowest hardness of bread was shown by the 100:0, was 1355.3 g for 55 min fermentation. Variations of composite flour ratios of wheat and cassava flours affected the color, aroma, taste, texture and overall acceptance of bread. The composite flour 100:0 gave the highest overall sensory acceptance, followed by the 80:20.

Keywords: bread, cassava, fermentation, sensory, texture

1. Introduction

The increase of wheat flour consumption in recent years in Indonesia brings the impact on food self-sufficiency, since the raw material is obtained through imports. In addition, the gluten in the flour has adverse effects on health, especially in children, such as celiac disease (Sapone, Bai, Ciacci, Dolinsek, Green, Hadjivassiliou, Kaukinen, Rostami, Sanders, Schumann, Ullrich, Villalta, Volta, Catassi, & Fasano, 2012) and some brain disorders such as autism (Buie, 2013) and epilepsy (Hernandez, Colina, & Ortigosa, 1998). One way to overcome this problem is to increase the utilization of local food to reduce the use of wheat flour, such as by using cassava flour.

Cassava flour is often used as a substituent of wheat flour in making bread. However, Nwosu, Justina, Owuamanam, Omeire, & Eke (2014) reported that the higher the substitution of cassava flour, the lower the sensory acceptance of bread. In other studies, Eriksson, Koch, Tortoe, Akonor, & Oduro-Yeboah (2014) stated that the higher portion of cassava flour substitution, the higher the hardness of bread. However, the elasticity and volume of bread are getting smaller.

The low quality of bread by increasing the proportion of cassava flour is not only caused by the low protein content, but also the fermentation and the volume of water that is not appropriate. Amjid, Shehzad, Hussain, Shabbir, Khan, & Shoaib (2013) reported that fermentation is an important factor that determines the quality of bread. The optimum fermentation affects the development of gluten tissue and the dough rheological properties. Belitz, Kieffer, Seilmeier, & Wieser (1986) suggested that water give important role in the formation of viscoelastic properties of the dough through the formation of disulfide and ionic bonds among protein compounds. Shewry, Popineau, Lafiandra, & Belton (2001) reported that if the amount of water used little or less in the process of forming the dough, then the interaction between the components will be hampered. However, if water is used excessively, it can also cause damage to the interaction between components. Rauf & Sarbini (2015) had shown that the use of the same volume of water for each level of composite flour can produce a dough that is not properly hydrated by increasing the proportion of cassava flour.

The water volume of composite flours of wheat and cassava in the dough-making can be determined proportionally based on the composite flours water absorption capacity, which is called proportional water volume (Rauf & Sarbini, 2015). Wheat flour and cassava flour have different water absorption (Nwosu, Justina, Owuamanam, Omeire, & Eke, 2014). This has an impact on the volume of water required difference in the proportion of different composite flour to form the dough with good interaction among the components.

The purpose of the research was to evaluate the physical characteristics and sensory of bread from the composite flours of wheat and cassava with optimum fermentation and the proportional water volume.

2. Materials and Methods

2.1. Materials

Ketan Jawa cassava variety was obtained from a farmer in Boyolali, Indonesia, harvested 9 months after planting. The hard wheat flour and other materials used in the research were obtained from super market in Surakarta, Indonesia.

2.2. Manufacture of Cassava Flour

The manufacture of cassava flour is done by following the procedure of Eduardo, Svanberg, Oliveira, and Ahrne (2013). Cassava was peeled and washed using flowing water. Furthermore, cassava was sliced thinly, followed by drying using a cabinet dryer at a temperature of 60°C for 24 hours. The dried strips were milled and sieved to 80 meshes.

2.3. Water Absorption Analysis

The analysis of water absorption was modified from Valdez-Niebla, Paredes-Lopez, Vargas-Lopez, and Hernandez-Lopez (1993), and Ju and Mittal (1995). A total of one gram of composite flour of wheat and cassava flours was added 10 ml of distilled water and mixed thoroughly using a vortex for 2 minutes. This was left untouched for 15 minutes and then centrifuged at 3000 rpm for 25 minutes. The supernatant was separated and the sample weighed. The difference between the weights of the sample after absorbing water per 100 g dry sample was expressed in percentage as water absorption of composite flour. The water absorption capacity was used as a reference to determine the volume of water to the making of the dough.

2.4. Dough Expansion Measurement

The dough was placed in a beaker for fermentation. During fermentation, the dough height was measured every 5 minutes, for 100 minutes. The optimum fermentation period was used as a reference for the next stage.

2.5. Bread Making

The composite flours of wheat and cassava (200 g) were mixed with sugar (4 g), salt (3 g), margarine (4 g), emulsifier (4 g), yeast (4 g), and water (65 % v/w of the composite flours) for 10 minutes. After fermentation, the dough was baked at temperature of 150°C for 20 minutes.

2.6. Bread Expansion Measurement

The bread height was used as a measure of expansion, followed the procedure of Codina, Mironeasa, Voica, & Mironeasa, (2013). The bread height was measured from the bottom to the top of the bread.

2.7. Texture Analysis

The measurement of hardness and elasticity of bread using a universal testing machine Z0.5 models from Zwick / Roell AG, Germany. The procedure as reported by Al-Saleh & Brennan (2012) and Dziki, Cacak-Pietrzak, Mis, Jonczyk, & Gawlik-Dziki, (2014). The amount of force applied was set from 0 to 25 N. The free pre-test, testing and post-test were each of 1.5 mm / sec, 2 mm / sec and 10 mm / sec. The hardness level is expressed as the amount of maximum compression force given on the bread to be deformed. Elasticity is the ratio of the height of bread after given a compression force to be relaxed with the previous high, which is expressed in a percentage.

2.8. Sensory Analysis

The sensory test was conducted by 30 panelists of Nutrition Science Department students of, Universitas Muhammadiyah Surakarta. All panelists have given written consent to be participants in the sensory test. The samples were tested for color, aroma, texture, taste and overall. Acceptance test was based on 7-point hedonic scale, namely 1 = dislike very much, 2 = dislike moderately, 3 = dislike slightly, 4 =neither like nor dislike, 5 = like slightly, 6 = like moderately, and 7 = like very much. The panelists were given an explanation of the samples to be tested and how to perform detailed testing. The panelists performed testing from the left sample to the right in sequence. Each sample was given 3-digit random number code. They then wrote the results of the sample tested for the color, aroma, taste, texture and overall acceptance. After that, the panelists tested the next sample. The samples that have been tested cannot be tested anymore.

2.9. Design and Statistical Analysis

Completely randomized design was used in the study. The composite flours ratios of wheat and cassava were 100:0, 90:10, 80:20 and 70:30. The data were analyzed using one-way ANOVA if normally distributed and the Kruskal-Wallis if not normally distributed, followed by Duncan's at a level 0.05.

3. Results and Discussion

3.1. Water Absorption Capacity

The water absorption of the composite flours is presented in Figure 1. The results showed that the higher portion of cassava flour from the composite flours, the greater the water absorption capacity. The water absorption capacity was consistent with those reported Rauf and Sarbini (2015).

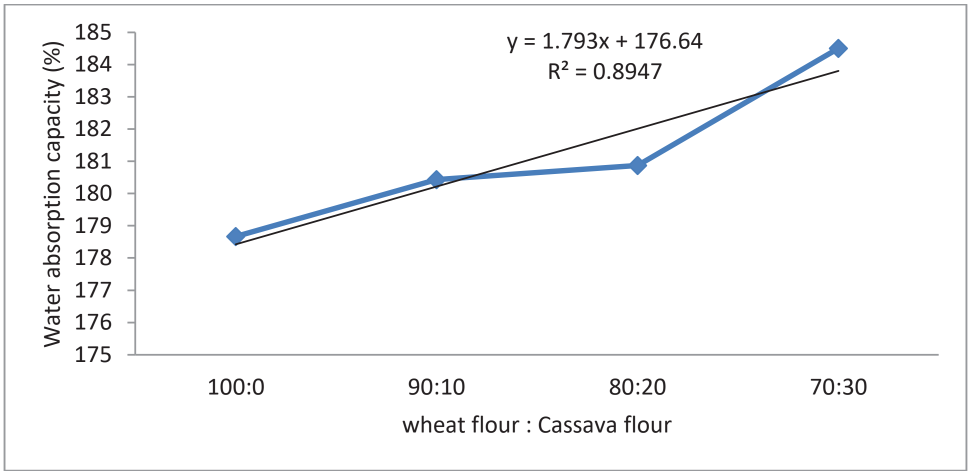

Figure 1. Water absorption capacity of composite of wheat and cassava flours

The water absorption of the composite flours gave a linear trend, with $R^2 = 0.8947$. The R-square value indicated that as many as 89.47 % of the water absorption was affected by the ratios of composite flours of wheat and cassava. Rauf and Sarbini (2015) had been reported that water absorption of the composite flour can be used as a reference to calculate the proportional water volume in the manufacture of dough. The volume of water from a mixture of flour and cassava flour 100:0, 90:10, 80:20, and 70:30, respectively of 65 mL, 65.6 mL, 65.8 mL and 67.1 mL for every 100 grams of the composite flours.

3.2. Dough Expansion

The results in Figure 2 revealed that all samples gave the same dough expansion trend, which were at the start of fermentation, and the height of the dough increased. Furthermore, the expansion of the dough reached the optimum point. The last stage was a decline in the level of dough expansion. Any variation of the composite flours displayed a difference in optimum point. Variations of the composite flours each provided the optimum level of fermentation, were in 55 minutes, 75 minutes, 65 minutes and 85 minutes, respectively. This indicated the differences in the speed of fermentation of each sample. According to Codina, Mironeasa, Voica, and Mironeasa (2013), the speed of high fermentation expressed in the high dough was a very important factor in the bread manufacture. Aboaba and Obakpolor (2010) reported that the difference in speed of dough fermentation from samples could be determined by the level of expansion.

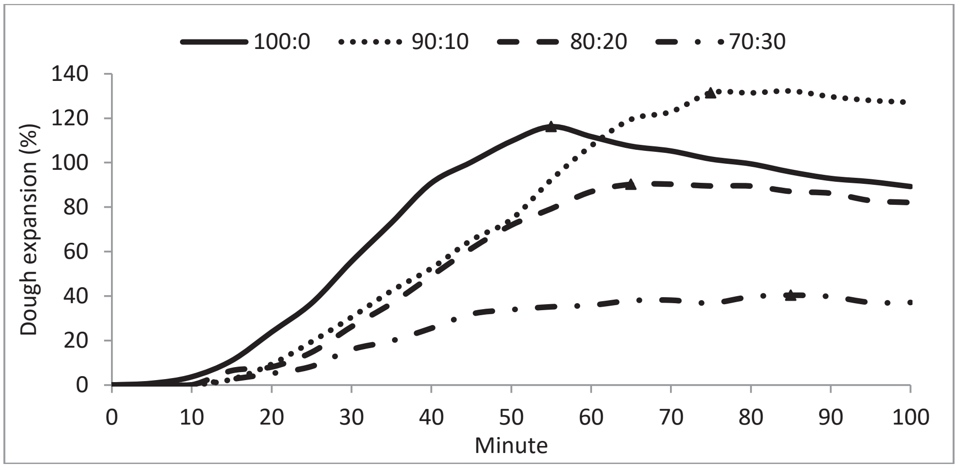

Figure 2. Dough expansion of composite of wheat and cassava flours during fermentation

At the optimum point, the highest expansion level of the dough was obtained from the composite flour in 90:10, and followed by the 100: 0. The differences in the expansion of the dough during fermentation of each treatment composite flours were not only affected by gluten, but also by water.
Sroan, Bean, and MacRitchie (2009) reported that the interaction between gluten and starch in the dough mixing, forming a matrix that can withstand the expansion of gases during the fermentation process. Mirsaeedghazi, Emam-Djomeh, and Mousavi (2008) explained that the matrix was formed by the cross bonds and non-covalent disulfide bonds. The matrix provided resistance to tensile strength. According to Rauf and Sarbini (2015), the dough from composite flours with 100: 0 and 90:10 ratio indicated the tensile strength were not significantly different. Water is a critical factor that determines dough expansion during fermentation (Amjid, Shehzad, Hussain, Shabbir, Khan, & Shoaib, 2013). The water volume used in each variation of composite flour differed in this study, depending on their water absorption. This is in line with the Rauf and Sarbini's (2015) report that the water volume used for the dough was proportional to its water absorption. Upadhyay, Ghosal, and Mehra (2012) reported that the amount of water affected the diameter of the cavity in the dough formed during fermentation.

3.3. Bread Expansion

The dough of each composite flour treatment was fermented at two-time points, which were at the optimum point and the point minus 10 minutes from the optimum point. After the dough was baked, then the expansion of bread was measured. According to Kasprzak and Rzedzicki (2010), the level of expansion was one factor that was often used in evaluating the quality of bread.

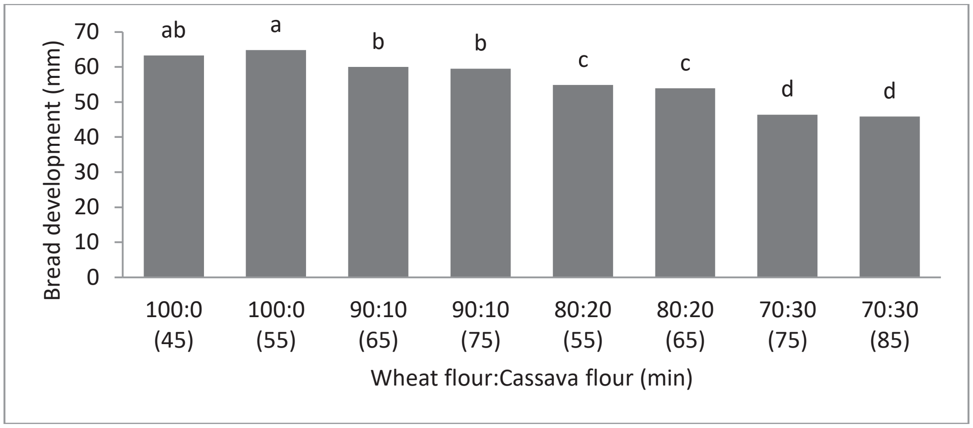

Figure 3. Bread expansion of wheat and cassava flours composites

Statistically, the results showed that there was the influence of variation of flour and cassava flour to the level of expansion of fresh bread, with *p*-value = 0.000. In Figure 3, it can be seen that the higher portion of cassava flour used, the lower the rate of bread expansion. The highest expansion level was given by bread of 100: 0 (64.9 mm), while the lowest expansion was shown by 70:30 (45.9). Rozylo, Dziki, Gawlik-Dziki, Cacak-Pietrzak, Mis, and Rudy (2015) explained that the type of raw materials influenced the level of bread expansion and the volume of water used.

In each of the same composite flour treatments, statistically showed that bread height was not significantly different for the two different fermentation time points. Aplevicz, Ogliari, and Sant'Anna (2013) reported a long-standing influence of fermentation on the bread production rate, but at two fermentation points close to each other, showing no significant differences.

3.4. Bread Texture

Hard bread crust is a description of the magnitude of the force required to deform the bread, expressed in units of the gram (g). Hardness is one indicator of the quality of bread, which is influenced by the ingredients used. The hardness level of the bread of flour and the flattened composite is presented in Figure 4.

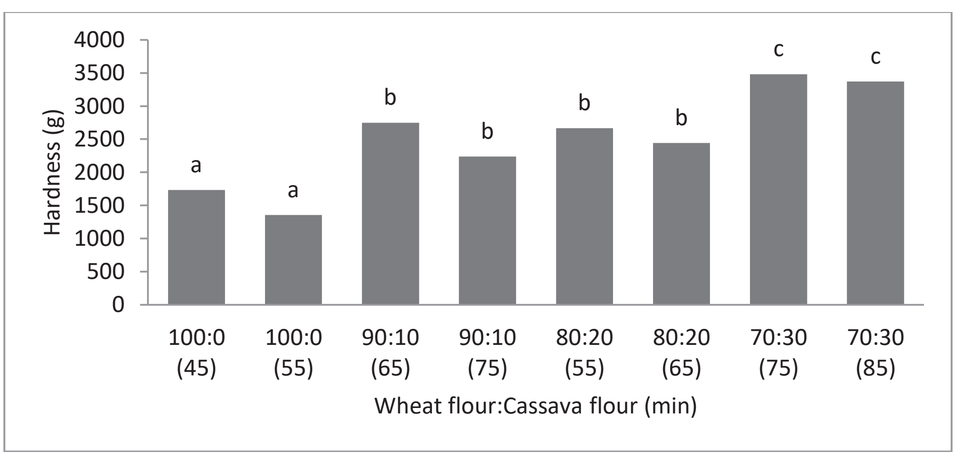

Figure 4. Bread hardness of composites of wheat and cassava flours

Statistically, there is the influence of variation of flour composite flour ratio and cassava to the hardness of bread, with *p*-value = 0.000. The higher the ratio of cassava flour used, the greater the hardness level of fresh bread. The highest hardness of bread was given by composite flour 70:30 (3482.7 g), while the lowest was shown by the composite flour and 100: 0 (1355.3 g). The hardness of the composite flours with the same ratios was not significantly different for the two different fermentation points.

The elasticity of bread was the amount of deformation in the bread given a force, thus the force was released. The result of the elasticity of fresh bread showed normal and homogeneous distributed data, therefore, statistically, ANOVA test was performed.

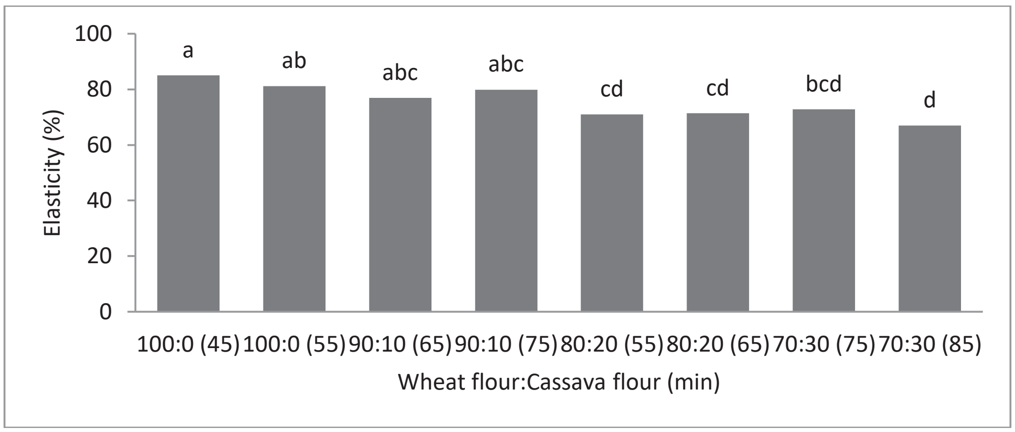

Figure 5. Bread elasticity of composite of wheat and cassava flours

Statistically, there was an influence of variation of composite flour ratio from wheat and cassava to bread elasticity, with value p = 0.006. In Figure 5, it appeared that the composite flour 100: 0 (85 %) gave the highest elasticity, while the lowest elasticity was given by the 70:30 (67 %). For the 100: 0 and 90:10 treatments, the elasticity was not significantly different. Different fermentation treatments for each variation ratio of wheat and cassava flours had shown no significant difference in elasticity.

3.5. Sensory Acceptance

Sensory acceptance of bread from composite flours of wheat and cassava for color, aroma, taste, texture and overall variables provided abnormally distributed data, therefore, Kruskal Wallis statistical tests were performed. There was an influence of variation ratio of the composite flours to the color, aroma, taste, texture, and whole of fresh bread, with the *p*-value of 0.000; 0.013; 0.001; 0.000 and 0.000. The results of the sensory test of bread were shown in Figure 6.

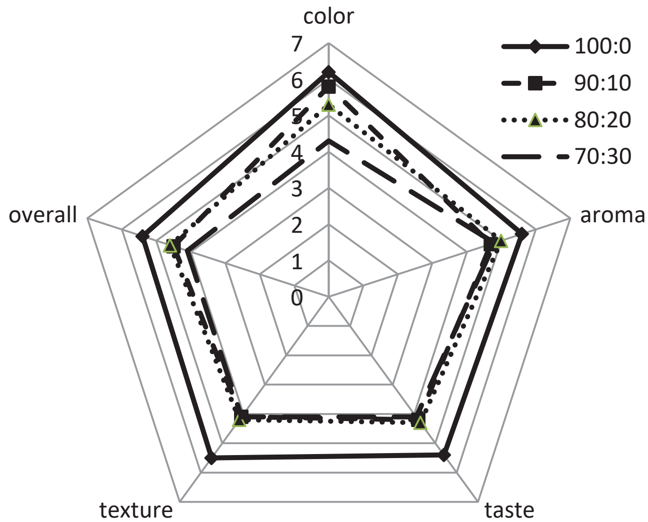

Figure 6. Sensory acceptance of bread from composite of wheat and cassava flours

The sensory data in Figure 6 for color indicated that there was a decrease in sensory acceptance with the higher portion of cassava flour. The 100:0 composite flour treatment gave an acceptance score that was not significantly different from the 90:10 treatment, with a "like moderately" panelists response. For the 80:20 composite flour treatment the response was "like slightly", while the 70:30 treatment provided a "neither like nor dislike" response.
The bread from the composite flour 100:0 indicated the highest acceptance of aroma, which was between "like slightly" and “like moderately”. Statistically, it was not significantly different from the 80:20, with the “like slightly” response level. The 90:10 and 70:30 treatments showed a “like slightly” and were not significantly different from the 80:20 treatment.
The taste and texture of bread, in general, gave a similar tendency. The composite flour of 100:0 showed the highest taste, with the response between "like slightly" and "like moderately". The 90:10, 80:20 and 70:30 treatments for taste and texture were statistically different from the 100:0. The three treatments provided a “neither like nor dislike” response.
The composite flour 100:0 gave the most preferred bread for the “overall” variable. It was significantly different from 90:10, 80:20 and 70:30 treatments. The three treatments showed the overall acceptance that was not significantly different.

4. Conclusion

There is the influence of composite flour ratio of wheat and cassava to expansion, texture and sensory acceptance of bread. The higher portion of cassava flour used, the lower the expansion and hardness of bread, while it will lower the elasticity. The composite flour 100:0 gives the highest overall acceptance, followed by the 80:20.

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