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The Effect of Beneng Taro (*Xanthosoma undipes* K.Koch) Flour Substitution on Physical and Sensory Characteristics of Muffins

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ABSTRACT

Beneng taro is an indigenous tuber that grows in Pandeglang, Banten. People of Pandeglang only use it in form of fried and steamed. Another effort to utilize beneng taro that has been done is to process it into flour. Beneng taro contains functional compounds including carotenoid pigments and dietary fiber. The use of beneng taro in food can increase product functionality and as food diversification . Muffins are one of the food that people like, but the main composition is wheat flour. The use of local flour in muffin can help the reduce of wheat flour, but will affect the characteristics of the resulting muffin. The purpose of this study was to evaluate the effect of adding beneng taro flour to muffins on the physical and sensory characteristics. This study used a completely randomized design (CRD) with concentration of substituted beneng taro flour (0%, 15%, 20%, 25%, and 30% w/w). The result of this research is the increase of beneng taro flour substitution in muffins decrease the expansion ratio, water content, lightness (L*) of the crust and crumb, a* chromaticity of the crust, b* chromaticity of the crust and crumb, hue (oh) of the crust and crumb, and sensory acceptance. However, The increase of beneng taro flour substitution increase the density of dough, density of muffin, and a* chromaticity of the crumb. The result of sensory evaluation showed that the increase of beneng taro flour substitution decrease the acceptance of aroma, taste, texture, and color. Based on the results of physical and sensory analysis, the muffin formula substituted with 15% beneng taro flour was the best formula.

Keywords: Beneng taro flour addition, food diversification, muffin

INTRODUCTION

Beneng Taro is an indigenous tuber of Banten Province which is commonly found in Pandeglang Regency. "Beneng" is an abbreviation of large (*besar*) and "koneng" (*kuning*) which comes from the Sundanese language which means big and yellow because it has a length of up to 120 cm, a weight of 42 kg, and a diameter of 50 cm (Haliza *et al*., 2012; Yursak *et al*., 2021). Beneng taro contains protein (6.25% wb), ash (3.43% wb), carbohydrate (84.88% wb), amylopectin (70.24% wb), crude fiber (2.29% wb), and dietary fiber (7.19% wb). This nutritional content of beneng taro is the highest among other types of taro (Apriani *et* *al*. 2011). The content of resistant starch, whose functional characteristics such as fiber in taro is greater than wheat and rice (Liu *et al*. 2006). The high content of dietary fiber and resistant starch can make beneng taro as food that has the effect of reducing the risk of coronary heart disease and cancer (Lattimer and Haub 2010). Beneng taro is also a good source of minerals, easy to digest, and absorbed by the body because of its small starch granule size (Yuniarsih *et al*. 2019). Minerals contained in taro include potassium, phosphorus, manganese, and copper (Temesgen and Retta 2015, Soudy *et al*. 2010). Beside that, beneng taro contains beta carotene pigment of 6.92 ppm (Budiarto and Rahayuningsih, 2017).

So far, the people of Pandeglang only use beneng taro by steaming and frying. Another effort to utilize beneng taro that has been done is to process it into flour. The advantages of processing beneng taro into flour is easier packaging and distribution, longer shelf life, and more practical processing. The addition of beneng taro flour in various food products has several objectives: 1) reducing the use of wheat flour and increasing the utilization of beneng taro, 2) increasing the nutritional value of the product, 3) increasing the functional value of a product such as carotene and dietary fiber (Rismaya *et al*. 2018).

One of bakery products that are consumed by many people today is muffin. Muffin is popular because it is practical and taste quite good. However, muffin has a weakness, it has low dietary fiber content. According to Rupasinghe *et al* (2008), the dietary fiber content of muffin made from 100% flour is only 1.30%, because wheat only has a small amount of dietary fiber, only 1.9% (Widaningrum *et al*. 2005).

The addition of beneng taro flour will affect the physical characteristics of the resulting muffins such as color, density, water activity, and expansion ratio. The addition of beneng taro flour is expected to increase the color of the muffins because it contains carotenoid pigments. Dietary fiber in beneng taro flour can affect the physical characteristics of muffin, including reducing expansion ratio, increasing density, reducing water activity, and decreasing organoleptic acceptance (Rismaya *et al*. 2016).

Based on the research of Rismaya *et al*. (2018), the addition of 25% pumpkin flour into muffin became the selected formula based on sensory quality and increased the value of dietary fiber. However, other quality parameters decreased compared to the control, including the volume of expansion decreased by 4%, the color parameter decreased by 31%, and sensory acceptance decreased by 16%. Based on research of Lestari and Maharani (2017), adding 20% of Belitung taro flour to white bread became the selected formula based on sensory quality compared to other formulas. However, other quality parameters decreased compared to the control, including the volume of expansion decreased by 30% and sensory acceptance decreased by 10%. Thus, the addition of beneng taro flour into the muffin in this study is to affect the quality of the muffins produced, so it is necessary to conduct research to determine its effect on the physical and organoleptic characteristics of the muffin.

MATERIALS AND METHODS

Tools and Materials

The material used in making muffin is beneng taro flour obtained from Talaga Warna Village, Pabuaran District, Serang Regency. Muffin raw materials obtained from Pasar Lama, Serang consist of wheat flour with medium protein (Segitiga Biru), margarine (Forvita), chicken eggs, salt (Dolpin), refined sugar (Gulus), mineral water (aqua), and Baking powder (koepoe-koepoe). The tools used are convection oven (Memmert, model UN55), aw meter

(Aqualab Pawkit), Chromameter (Hunterlab Colorflex EZ), desiccator, analytical balance (Excellent, model HZK), crucibles, sensory booth, mixer (Philips, model HR 1552), oven (Cosmos, model CO-9919R), microwave (Samsung, model MS23K3515AS), muffin tin mold, glassware (Pyrex), stationery, paper, millet, muffin cups and kitchenware.

Method

This study was conducted using five treatments, namely control muffins (100% wheat flour), muffins substituted with beneng taro flour with concentration of 15%, 20%, 25%, and 30% and carried out two replications. The research had been carried out in two stages, namely muffin production, and physical and organoleptic properties testing each of which is tested in duplicate. The physical tests carried out were water activity, water content, batter density, muffin density, expansion ratio, and color. The sensory tests carried out were aroma, taste, texture, and color of muffin.

Muffin Production

The formula for the beneng taro muffin refers to the research of Purnomo *et al*. (2014) with modification (Table 1). The flour is sifted to 60 mesh and weighed then put into the mixer bowl. Margarine, water, and salt that have been melted in the microwave are then put together in a mixer bowl and mixed with flour. Chicken eggs are added gradually into the batter and then stirred, then powdered sugar and baking powder are added to the batter and stirred. Batter pour into the muffin cup until ¾ height. The size of the muffin cup used is 4 cm in diameter and 3 cm in height. Then the batter is baked in an electric oven at 200°C for 25 minutes.

Water Content Analysis

Water content analysis refers to the AOAC (2006) method. Empty aluminium crucibles were dried in a convection oven at a temperature of 105°C to constant and weighed (W2). Furthermore, the muffin sample as much as 2 grams (W) was put into a cup and dried in an oven at 105°C until the sample was constant. Then the crucibles containing the sample was weighed its final weight (W1).

$$\text{Water Content (\%wb)} = \frac{W-(W2-W1)}{W} \times 100\%$$

Water Activity (aw) Analysis

The water activity (aw) of muffins was measured using an aw meter according to Ulfah *et al*. (2018), the sample is put into a tube and then put in an aw meter. The screen will show the measurement progress. After the value is stable, the instrument will sound which indicates the water activity measurement process has been completed.

Batter and Muffin Density Analysis

Batter and muffin density analysis are refers to Hasmadi (2010). Density is measured by dividing the weight of the material by the volume of space it occupies. The weight of the batter and muffin products was measured by weighing the muffins using an analytical balance. The volume of muffin batter is measured using a measuring cup by making the weight of the batter as a reference in determining the volume of batter that is put into the muffin cup. Meanwhile, the volume of muffin products was measured using the seed displacement method, using millet as the grain. The millet seeds are put into the measuring cup until the surface is flat, the container is knocked ten times so that all the space in the cup is filled. Furthermore, some of the seeds in the cup are temporarily transferred to another cup. Next, the muffin is put into a measuring container that contains some of the millet seeds and the container is filled with the millet seeds until it is completely flat. The remaining millet seeds were measured in volume with a measuring glass to determine the volume of the muffin (mL). Furthermore, the muffin density was calculated based on the result of dividing the muffin weight by the muffin volume (g/mL).

Expansion Ratio Analysis

The expansion ratio analysis refers to Rismaya *et al.* (2018). Method using seed displacement. The expansion ratio is the ratio between the volume of muffins after baking divided by the volume before baking multiplied by one hundred percent. Muffin volume was measured using the seed displacement method with millet seeds. The millet seeds are put into the measuring container until it is completely flat. After the container is full, some of the seeds are temporarily transferred to another container, then the muffins are put into the container and filled again with millet seeds from another container until they are completely flat. The remaining millet seeds were measured with a measuring cup as the volume of the muffin. The volume of the batter is determined using a measuring cup, muffin batter is first put into the measuring cup and the volume is recorded.

Color Analysis

Color analysis refers to Matos *et al*. (2014) by modifying the type of instrument used. Matos *et al*. (2014) using Konica Minolta CM-3500 chromameter. While the instrument used is the Hunterlab ColorFlex EZ. Color analysis was carried out on the crumb and crust of muffin. Measurement of the crust by placing the sample in the container directly, while the measurement of crumb by cutting the whole muffin at a ¾ height of the top and placing it in the container. Color measurement with the CIELAB system produces values of L*, a*, and b*. the value of L* indicates brightness with a value of 0 (black) to 100 (white), the value of a* indicates green (-a*) to red (+a*) and the value of b* indicates blue (-b*) to yellow (+b*). The degree of hue (^{o}h) is calculated as $\tan^{-1}(b^*/a^*)$.

Hue 342-18 : Red purple
Hue 18-54 : Red
Hue 54-90 : Yellow red
Hue 90-126 : Yellow
Hue 126-162 : Yellow green
Hue 162-198 : Green
Hue 306-342 : Purple
Hue 270-306 : Blue purple
Hue 198-234 : Blue green
Hue 234-270 : Blue

Sensory Analysis

Sensory hedonic analysis was carried out using the BSN (2006) method based on SNI 01-2346-2006 regarding sensory testing standards. This test aims to determine the level of consumer preference and opinion regarding the beneng taro muffin product. This test was carried out by 35 panelists of Food Technology students, University of Sultan Ageng Tirtayasa with an age range of 19-21 years with female and male gender. The panelists have been given technical guidance on how to give scores on a hedonic scale of 1-7, namely 1: dislike very much, 2: dislike, 3: rather dislike, 4: neutral, 5: rather like, 6: like, 7: really like. This test is carried out with 4 parameters, namely taste, color, aroma, and texture.

Statistical Analysis

The research design used was a completely randomized design (CRD) with one factor, namely flour substitution with beneng taro flour consisting of 2 replications and 5 levels, namely 0%, 15%, 20%, 25%, and 30% w/w. The data obtained then analyzed with ANOVA (Analysis of Variance) at =5% to determine the significant effect on each test parameter. If it shows a significant difference, then proceed with Duncan's Multiple Range Test (DMRT) at $\alpha = 5\%$.

RESULTS AND DISCUSSION

Expansion Ratio

The expansion ratio is one of the important parameters in muffin acceptance. The large volume expansion reflects a more hollow and porous structure, so it has a good acceptability value (Rismaya *et al*. 2018). Based on the results of Duncan's further test, Table 2 shows the average of muffin expansion ratio is decreased with the increase of concentration of beneng taro flour, the results showed a significant difference from muffins which were substituted for beneng taro flour by 15%.

The decrease in the expansion ratio due to an increase in the concentration of beneng taro flour was associated with a decrease in the gluten tissue formed due to the increase of dietary fiber content of beneng taro flour in the batter. The gluten tissue of gliadin and glutenin proteins plays a role in the formation of an elastic film layer that can hold carbon dioxide, so that uniform pores are formed (Wulandari and Lembong, 2016). According to Lestari and Susilawati (2015), beneng taro flour does not have a protein that forms the structure of the gluten tissue which causes a decrease in gluten in the batter. The decrease in the formation of gluten tissues in the batter causes the batter's ability to retain gas during baking to be reduced, so the resulting expansion ratio is low.

The presence of water in the batter is also thought to affect the rheological characteristics of the batter and the quality of muffin products. Water in the batter besides helping the formation of the gluten tissue structure is also needed for the starch gelatinization process, this process is important in the formation of the cake structure (Rismaya *et al*. 2018). According to Muhandri and Subarna (2009), an increase in the water content of the batter causes more water to diffuse into the starch granules which can cause the starch granules to swell and become irreversible, thereby increasing starch gelatinization. The increase in the degree of gelatinization causes more amylose to be released from the starch granules, which functions as a binder which together with the gluten tissue can produce an elastic and cohesive batter mass. The elastic batter plays a role in the formation of the muffin form tissue, so it can be pushed by gas during the baking process.

Dietary fiber has high absorption and water holding capacity which can affect the elasticity of the batter (Struck *et al.* 2016). The dietary fiber content of beneng taro flour reaches 9.52% (Putri *et al.* 2021), while the dietary fiber content of wheat flour is only 1% (USDA, 2022). The higher dietary fiber, the more water will be absorbed, thus lowering the expansion ratio, therefore the more addition of beneng taro flour, the higher the food fiber content will be, and the more water will be absorbed, so the smaller the muffin expansion ratio (Rismaya *et al*. 2018). Water in the batter which is bound by beneng taro dietary fiber will cause the hydration process of starch in the batter to be disturbed so that the starch gelatinization process is hampered and results in decreased elasticity of the batter, less elastic batter causes the formation of muffin structures to be disturbed, as a result of the batter's ability to hold gas during baking decreases.

These results are in similiar with research by Rismaya *et al.* (2016) which substituted pumpkin flour in muffins and Permatanisa and Murtini (2021) research which added soursop puree to muffins. Pumpkin flour has dietary fiber of 14.81% (Trisnawati *et al.*, 2014). The research results of Rismaya *et al.* (2016) showed that the expansion ratio of muffins added with pumpkin flour by 25% decreased to 3% compared to the control. Soursop puree has as much as 3.41% fiber (USDA, 2022). The results of the research by Permatanisa and Murtini (2021) showed that the expansion ratio for muffins that were added 15%

soursop puree decreased to 24% compared to the control.

Density

Density is calculated based on the ratio between the mass of the material and the volume it occupies. A low density value indicates a small mass can fill a large space. The higher the density value, the more compact or dense the product is (Rismaya *et al*. 2018).

Based on the results of Duncan's further test, Table 2 shows the average density of muffin batter, which increases with the concentration of added beneng taro flour, the results show a significant difference starting from the muffin batter substituted with 15% beneng taro flour. A large batter density is thought to reduce the muffin expansion ratio (Rismaya *et al*. 2018). The substitution of beneng taro flour increased the density of the batter and decreased the batter expansion during baking.

The same thing happened to the average density of muffins which increased with the increase of the addition concentration of beneng taro flour. The results showed a significant difference ($p<0.05$) starting from the muffin dough which was substituted for beneng taro by 15%. The increase in the density of the substitution muffin was influenced by the high dietary fiber contained in the beneng taro flour. Similar research conducted by Struck *et al*. (2016) showed that the density of muffins can be increased by substituting several sources of dietary fiber (wheat fiber, pea fiber, apple fiber). In addition, research by Rismaya *et al*., (2018) also showed that the addition of 25% pumpkin flour would increase the muffin density by 31%. Muchtadi (2001) stated that the total dietary fiber component can increase the density of a material or product. Resistant starch can cause crumb muffin matrices to become compact (Baixauli *et al*. 2008). The compact and dense crumb structure causes the muffin volume to be low, so the density of the resulting becomes high.

The higher product expansion ratio value, the lower the density produced. High expansion causes the product have a low mass but high volume, so the density value is low. The high expansion ratio can be described by the shape of the particles which are hollow and porous. The smooth and uniform hollow structure can be used for by the batter's ability to hold gas. Pumpkin flour substitution to muffin decreased the batter's ability to hold gas, resulting in a less hollow structure. Less hollow structures have a low volume with a large mass, resulting in a high density (Rismaya, 2016).

Water Content and Water Activity

Water content is an important component that can determine the stability and durability of food products. In table 2 can be seen that the highest average water content of muffin products is in control muffins (10.53%±0.44), and the lowest is muffins substituted with beneng taro flour by 30% (8.95%±0.14). Based on further tests with Duncan, there were significant differences ($p<0.05$) in the water content of control muffins and those substituted with beneng taro flour, while between muffins substituted with beneng taro flour with various concentrations, there was no significant difference ($p>0.05$). In general, the more the concentration of beneng taro flour is added, the water content will decrease. The results are similar with the research of Permatanisa and Murtini (2021) that muffins substituted with 15% soursop puree has a 2% decrease in water content compared to controls and Rismaya et *al.,* (2018) who added 80% pumpkin flour to muffins resulted in a decrease water content as much as 2% compared to control.

Rismaya *et al*. (2018) stated that the addition of pumpkin flour which is high in fiber in the muffins causes a decrease in the value of water content compared to muffins made from wheat flour. The decrease in the water content of the muffins with the increasing concentration of added taro beneng flour was related to the ability of dietary fiber to bind water. The ability of dietary fiber to bind water is related to the role of hydrophilic groups (Winaktu and Gracia, 2011). According to Kusnandar (2010), water chemically bound to hydrophilic groups is hard to remove during the drying process, so that less free water molecules are evaporated. In the beneng taro muffin batter, some of the water is bound by dietary fiber which results in a decrease in free water that can be evaporated, thereby lowering the water content of the beneng taro muffin.

While water activity (aw) is the amount of available water that can be used for enzymatic reactions and microbial growth. Water that can be used for reactions and microbial growth is free water, while the type of water that is evaporated is free water and weakly bound water (Kusnandar, 2010). In table 2, based on Duncan's further test results on aw muffins, there were no significant differences in all muffin formulas ($p>0.05$).

Lightness (L*)

Color is an important factor that is first seen by consumers in determining the acceptance of a product. Color measurement in this research is important to determine the effect of beneng taro flour substitution treatment on the color quality of the resulting muffins. Color testing is carried out on the crust and crumb of muffin.

The L* value represents the lightness parameter with a value of L*=0 meaning black and L*=100 meaning white (Andarwulan *et al*. 2011). Table 3 shows that the value of L* crumb muffins substituted with beneng taro, from the results of further tests was significantly different from the control ($p<0.05$). In general, the higher the substitution of beneng taro, the lower the lightness value of muffin crumb. These results are in similar with research by Rismaya *et al*. (2018) which showed that adding 25% of pumpkin flour to muffins would reduce the L* value by 30% compared to the control. Research by Budoyo *et.al* (2014) also showed that adding 15% of pumpkin flour would reduce the L* value by 13%.

Table 3 shows that the L* value of crust muffins substituted with beneng taro flour at concentration of 25% and 30%, from the further test results were significantly different from the control, but the muffins substituted with beneng taro flour with 15% and 20% were not significantly different from the control. In general, the higher the substitution of beneng taro flour, the lower the lightness value of the muffin crust.

The value of L* in crust ranged from 29.07-39.79 while the value of L* in crumb ranged from 50.21-67.14. This data shows that the lightness of the crust is lower than the crumb. Pictures of muffins with varying concentrations of beneng taro flour can be seen in Figure 1. As beneng taro flour along with wheat flour is a contributor of protein, so intense Maillard browning reaction occurred in the crust, the crumb does not undergo Maillard reaction, but is affected by the ingredients in the batter. Intense maillard browning makes the color of the crust is darker than crumb (Conforti and Davis, 2006).

The decrease in the lightness value of L* in substitution muffins was influenced by the difference in the color of the flour used as raw material of muffins. Beneng taro flour has a darker color (low L*) than wheat flour (Wongsagonsup *et al*. 2015; Rostianti *et al*. 2018). Beneng taro flour has a yellow color due to the presence of carotenoid pigments of 6.92 ppm (Budiarto and Rahayuningsih 2017). The decrease in lightness value (L*) is also influenced by the formation of brown color due to non-enzymatic browning reactions (Maillard reaction). The formation of brown color is more dominant in the substitution muffins due to the high content of reducing sugar in the beneng taro flour. In addition to the presence of amino acids and reducing sugars, the Maillard reaction is also influenced by water content (Laguna *et al* 2011; Kusnandar 2010). The high water content in the batter tends to shift the reaction towards the formation of N-substituted glycosylamine as a precursor for the formation of melanoidin compounds to be inhibited (Kusnandar, 2010). This melanoidin compound plays a role in the formation of the brown color in muffins. In muffins substituted with beneng taro flour, the presence of water is bound to dietary fibers so that the presence of water in the batter is reduced. The presence of low water in the beneng taro batter muffin causes the reaction to shift towards the formation of more melanoidin compounds, until the brown color becomes more dominant. These results are in accordance with the research of Rismaya *et al*. (2018) which stated that the lower water content of the batter causes the color of the pumpkin muffins to be darker.

a* Chromaticity

The a* chromaticity value indicates green (negative) to red (positive) color (Santoso *et al*. 2013). The average value of a* chromaticity of crust muffins produced ranged from 14.24-19.26, and the average value of a* chromaticity of crumb muffins ranged from 5.93-8.36, with the highest average of a* chromaticity obtained in muffins substituted with 30% beneng taro flour ,namely 8.36 for crumb and 19.26 for crust, and the lowest average value of chromaticity a* was found in muffin control, namely 5.93 for crumb and 14.24 for crust. The average value of a* chromaticity of muffins shows that the average value of a* chromaticity is positive which indicates a tendency towards the red color.

Table 3 shows that the values of a* crust muffins in substitution of beneng taro flour from the further test results were significantly different from the control ($p<0.05$), Significantly different results were shown starting with substituted muffins of 20%. In general, the higher the substitution of beneng taro flour, the lower a* chromaticity value of the muffin crust. Table 3 shows that the a* chromaticity value of the beneng taro crumb muffin of substitution was 30%, the results of the further test were significantly different from the control but not significantly different from the other formulas. In general, the higher the substitution of beneng taro flour, the higher the value of a* chromaticity crumb muffin.

The results of a* chromaticity in crumbs indicate a tendency that the higher concentration of substituted beneng taro flour added, the higher a* chromaticity value. A high a* chromaticity value was found in muffins with a dark surface (L* low) (Rismaya 2016). These results are in similiar with the study of Budoyo *et al*. (2014) which showed an increase of 66% in the a* chromaticity muffin substituted with pumpkin flour by 15% compared to the control. The increase in a* chromaticity value was influenced by the formation of a more dominant brown color resulting from the Maillard reaction that occurred in the batter. While the chromaticity value of a* crust muffins shows the opposite, this is presumably due to the effect of oven baking which produces a slightly uneven heat on the surface of the muffin crust so that it accelerates the formation of color tends towards redness on the surface of the muffin which is more exposed to heat than crumb.

b* Chromaticity

The value of b* chromaticity shows a blue (negative) to yellow (positive) color

(Santoso *et al*. 2013). The average value of b* chromaticity crust muffins produced ranged from 17.33-31.94, and the average value of b* chromaticity crumb muffins ranged from 25.81-37.09, with the highest average of b* chromaticity obtained at 30% control muffins, namely 37.09 for crumb and 31.94 for the crust. The average value of b* chromaticity of muffins shows that the average value of b* chromaticity is positive which indicates a tendency towards yellow.

Table 3 shows that the value of b* chromaticity crust muffins with substitution of beneng taro flour of 20%, 25%, and 30%, from the further test results were significantly different from the control ($p<0.05$), Significantly different results were shown starting with muffins which were substituted by 20%. In general, the higher the substitution of beneng taro flour, the lower the of b* chromaticity crust muffins. Table 3 shows that the b* chromaticity values of crumb muffin at concentrations of 15%, 20%, 25%, and 30%, from the further test results were significantly different from the control ($p<0.05$).

These results are similiar with the study of Budoyo *et al.*, (2014) which showed a 20% decrease in the b* chromaticity value muffin substituted with pumpkin flour by 15% compared to control. The more concentration of substituted beneng taro flour in muffins causes a decrease in the value of b* chromaticity which is thought to be due to the yellow-orange color due to the natural pigment content of beneng taro (carotenoids) and the formation of dark brown color resulting from the Maillard reaction is more dominant in substitution muffins (Rismaya, 2016). The decrease of b* chromaticity because of the forming of melanoidin pigment from Maillard reactions from baking process. The presence of carotenoid pigments in muffin is covered by melanoidin pigments (Rismaya, 2016).

Hue (°h)

Chromatic color or Hue is a real color that can be observed by the eye, such as red yellow blue, green and so on (Andarwulan *et al*. 2011). The measurement values of L*, a* chromaticity and b* chromaticity can be converted to Hue (°h) values (Santoso *et al*. 2013). In general, the Hue of crust muffin values obtained ranged from 87.93-102.40 which indicated the color range of yellow red (Hue 54-90) and yellow (Hue 90-126). Meanwhile, the value of Hue crumb muffins obtained ranged from 125.78-141.29 which indicated the yellow color range (Hue 90-126) and yellow green (Hue 126-162). Table 3 shows that further test results showed that all muffins with various concentrations of beneng taro flour showed a Hue crust value that was not significantly different with control muffins ($p>0.05$). However, based on the results of further tests showed that all muffins with various concentrations of beneng taro flour showed significantly different hue crumb values with the control ($p<0.05$), the hue value showed a significant difference in muffins which were substituted for beneng taro flour by 30%. In general, the higher the concentration of beneng taro flour substitution, the lower hue value in the crust and crumb muffins.

These results are consistent with research by Rismaya (2016) which showed a 12% decrease in hue values in muffins substituted with pumpkin flour by 25% compared to controls. This decrease of hue value indicates the color of the muffins substituted with beneng taro flour tends to yellow for the crust and greenish yellow for the crumb which is more dominant. Meanwhile, wheat flour did not have a yellow and greenish yellow color, so the control muffins did not have a greenish crumb color and a yellowish crust. According to Muchtadi (2010), the difference in the color of the crumb in the product is strongly influenced by the color of the flour used as raw material. Beneng taro flour has a yellow color that comes from carotenoid pigments. Carotenoid pigments in beneng taro flour about 6.92 ppm (Budiarto and Rahayuningsih, 2017). In addition, the color difference is also influenced by the formation of a brown color due to the Maillard reaction that occurs between reducing sugars and free amine groups (Man *et al*. 2014; Struck *et al*. 2016). The higher sugar and starch content of beneng taro, which is 81.81% (Kusumasari *et al*., 2019) causes the formation of brown color due to the Maillard reaction to occur more in substitution muffins.

Sensory Characteristics

Aroma is one of the sensory properties received by the sense of smell that can affect the level of sensory acceptance. Based on table 4, Duncan's further test results showed that there were no significant differences aroma in all types of muffin formulations ($p>0.05$), the value shows that panelists give neutral acceptance. These results are in similar with the research of Lestari and Susilawati (2015) who substituted beneng taro flour for noodles, giving the result that the higher the concentration of beneng taro flour did not give significantly different results to the aroma. This result is presumably because the aroma of beneng taro flour tends to be neutral so that it does not have a significant effect on the panelists' sense of smell even though there is a difference in the concentration of substituted beneng taro in muffins.

Color is a factor that must be considered in product development, because panelists will evaluate the product first through its visual appearance. Based on table 4, Duncan's further test results showed that there was a significant difference in panelists' acceptance of the color of the control muffins with muffins substituted with beneng taro flour in various concentrations ($p<0.05$). Panelists give neutral for color for the muffin. The more beneng taro flour added to the muffins will cause a decrease in color acceptance because the resulting color impression is dark due to the presence of amino acid, carotenoid pigments, and the Maillard reaction that causes brown color due to the higher sugar and starch content of beneng taro than wheat flour. Carotenoid pigments in beneng taro flour about 6.92 ppm (Budiarto and Rahayuningsih, 2017). These results are in similair with the research of Lestrai and Susilawati (2015), the more taro beneng flour added to the noodles, the panelist's preferred color will decrease due to browning. In addition, because the brown color of flour is caused by the content of the amino acid lysine in taro tubers which will increase the brown color, lysine contains two amino groups so that it is more reactive to reducing sugars and produces a more concentrated brown color (Kurniawati and Ayustaningwarno, 2012).

The taste attributes depend on the composition of the ingredients used in the production of the product. Table 4 shows the results of Duncan's further test showing that the level of panelists' acceptance of the control muffin taste was significantly different ($p<0.05$). Significantly different results began to be shown in muffins which were substituted for beneng taro flour by 15%. The acceptance of the muffin control taste was rather like while the other four tended to be neutral. The higher the concentration of beneng taro flour, it tends to decrease the panelists' acceptance of taste. This is due to the high content of oxalate compounds in beneng taro flour, which is 648.87 ppm (Budiarto and Rahayuningsih, 2017). The more addition of beneng taro flour, the higher the oxalate compounds it contains. Oxalate compounds can stimulate the oral cavity and skin, causing itching or irritation. This itching effect can occur when calcium oxalate crystals are released and can irritate the skin causing small holes on contact (Aviana and Loebis, 2017).

Texture is one of the sensory properties of food products that are important in consumer acceptance. One of the parameters for good muffin quality is the crumb texture which is soft and not hard (Rismaya *et al.,* 2018). Table 4 shows that the results of Duncan's advanced test showed no significant difference between the control and muffins substituted with 15-25% taro flour ($p>0.05$), and began to show significant differences with muffins substituted with 30% ($p<0.05$). The panelist's assessment of the muffins substituted for beneng taro flour was somewhat disliking to neutral. The results of this study are in accordance with Rismaya *et al*. (2018) and Budoyo *et al.* (2014) which showed that the more pumpkin flour added to the muffins, the lower the panelist acceptance. Gluten is able to form films that are not easily torn, elastic, and extensible so that they can trap CO2. Substitution of flour with a higher dietary fiber content than wheat will reduce the availability of gluten so that the gas trapping ability also decreases causing the texture of the muffins to become tougher (Budoyo *et al.,* 2014).

CONCLUSION

The increase of beneng taro flour substitution in muffins decrease the expansion ratio, water content, lightness (L*) of the crust and crumb, a* chromaticity of the crust, b* chromaticity of the crust and crumb, hue (^oh) of the crust and crumb, and sensory acceptance. However, The increase of beneng taro flour substitution increased density of batter, density of muffin, and a* chromaticity of the crumb. Changes in the physical and sensory properties of muffins are related to the presence of dietary fiber in beneng taro flour. Based on the results of physical and sensory analysis, the muffin formula substituted with 15% beneng taro flour was the best formula. Although the control muffins had a higher acceptance score by panelists, expansion ratio, lightness, and hue, but the muffins substituted with beneng taro flour presence of functional components of dietary fiber and can help reduce the using of wheat flour.

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Table 1. Muffin basic formula design

Ingredient (g)	F1	F2	F3	F4	F5
Wheat Flour	525	446.25	420	393.75	367.5
Beneng Taro Flour	-	78.75	105	131.25	157.5
Margarine	345	345	345	345	345
Water	163	163	163	163	163
Salt	3	3	3	3	3
Chicken Egg	300	300	300	300	300
Refined Sugar	380	380	380	380	380
Baking Powder	10	10	10	10	10

Note: F1 = Control / Concentration of Wheat Flour 100%, F2 = Concentration of Beneng Taro Flour 15%, F3 = Concentration of Beneng Taro Flour 20%, F4 = Concentration of Beneng Taro Flour 25%, F5 = Concentration of Beneng Taro Flour 30%

Table 2. Average Value of several physical properties of muffins

Formula	Expansion Ratio (%)	Batter Density (g/mL)	Muffin Density (g/mL)	Water Content (%)	Water Activity
F1	276,56±2,21[a]	1,15±0,01[a]	0,37±0,02[a]	10,53±0,44[a]	0,67±0,03[a]
F2	245,83±3,54[b]	1,21±0,00[b]	0,44±0,01[b]	9,31±0,12[b]	0,70±0,01[a]
F3	238,39±3,79[bc]	1,30±0,00[c]	0,47±0,00[b]	9,02±0,12[b]	0,71±0,00[a]
F4	235,04±4,09[c]	1,31±0,00[c]	0,47±0,02[b]	8,96±0,14[b]	0,71±0,05[a]
F5	225,89±1,26[d]	1,35±0,00[d]	0,52±0,03[c]	8,95±0,14[b]	0,71±0,02[a]

Note: F1 = Control / Concentration of Wheat Flour 100%, F2 = Concentration of Beneng Taro Flour 15%, F3 = Concentration of Beneng Taro Flour 20%, F4 = Concentration of Beneng Taro Flour 25%, F5 = Concentration of Beneng Taro Flour 30%, Value with different notation in the same column has a significant difference at 5% (Duncan test)

Table 3. Average Value of muffin color attributes

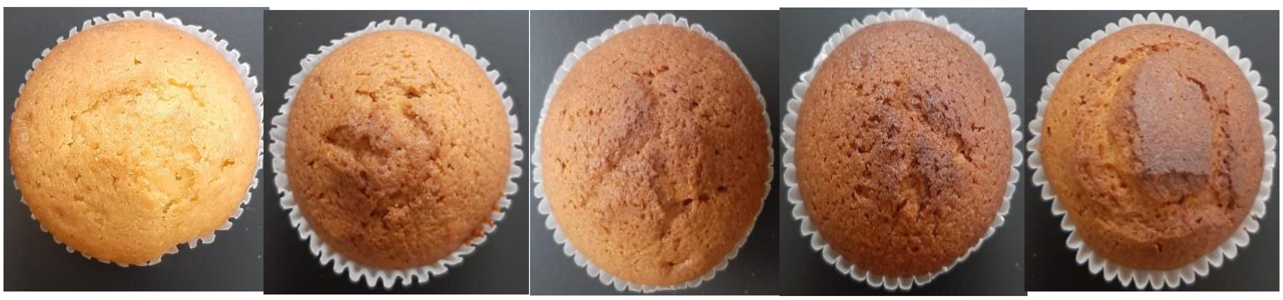
Part of Muffin	Formula	Color Attributes			
		L*	a*	b*	Hue (°h)
Crust	F1	39,79±3,64[a]	19,26±0,63[a]	31,94±3,93[a]	102,40±6,87[a]
	F2	38,53±2,97[a]	18,11±0,58[ab]	28,33±3,11[ab]	99,90±6,12[a]
	F3	34,30±2,54[ab]	17,03±0,39[bc]	23,58±2,39[bc]	94,30±4,20[a]
	F4	30,77±0,59[b]	16,18±0,42[c]	19,85±1,52[c]	88,60±2,47[a]
	F5	29,07±1,04[b]	14,24±1,30[d]	17,33±2,90[c]	87,93±4,41[a]
Crumb	F1	67,14±1,06[a]	5,93±0,84[a]	37,09±2,53[a]	141,29±1,14[a]
	F2	54,64±0,07[b]	7,30±0,54[ab]	26,34±3,95[b]	129,85±1,97[b]
	F3	52,10±1,92[bc]	7,48±0,14[ab]	23,95±1,39[b]	126,75±1,11[bc]
	F4	50,32±0,63[c]	7,52±0,20[ab]	23,26±0,32[b]	125,93±0,37[bc]
	F5	50,21±0,54[c]	8,36±0,26[b]	25,81±0,06[b]	125,78±0,85[c]

Note: F1 = Control / Concentration of Wheat Flour 100%, F2 = Concentration of Beneng Taro Flour 15%, F3 = Concentration of Beneng Taro Flour 20%, F4 = Concentration of Beneng Taro Flour 25%, F5 = Concentration of Beneng Taro Flour 30%, Value with different notation in the same column has a significant difference at 5% (Duncan test)

Table 4. Average panelist acceptance level of muffin sensory attributes

Formula	Panelist Acceptance Level			
	Aroma	Color	Taste	Texture
F1	4,43±1,20[a]	6,14±1,09[a]	5,46±1,24[a]	4,63±1,40[a]
F2	4,77±1,24[a]	5,43±1,09[b]	4,86±1,22[ab]	4,43±1,29[a]
F3	4,60±1,54[a]	3,57±1,31[c]	5,11±1,08[ab]	4,31±1,32[a]
F4	4,14±1,38[a]	4,23±1,42[c]	4,80±1,45[c]	4,46±1,52[a]
F5	4,26±1,36[a]	3,60±1,63[c]	4,54±1,27[c]	3,34±1,35[b]

Note: F1 = Control / Concentration of Wheat Flour 100%, F2 = Concentration of Beneng Taro Flour 15%, F3 = Concentration of Beneng Taro Flour 20%, F4 = Concentration of Beneng Taro Flour 25%, F5 = Concentration of Beneng Taro Flour 30%, Value with different notation in the same column has a significant difference at 5% (Duncan test)



F1 F2 F3 F4 F5

Figure 1. Beneng Taro Muffins with Different Formulations
Note: F1 = Control / Concentration of Wheat Flour 100%, F2 = Concentration of Beneng Taro Flour 15%, F3 = Concentration of Beneng Taro Flour 20%, F4 = Concentration of Beneng Taro Flour 25%, F5 = Concentration of Beneng Taro Flour 30%