UDC 66; DOI 10.18551/rjoas.2024-01.17

EFFECT OF MORINGA (MORINGA OLEIFERA) LEAVES FLOUR AND BAKING TIME ON NUTRITIONAL CONTENT AND ORGANOLEPTIC VALUES OF MUFFINS

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ABSTRACT
Muffins are made from wheat flour as the main ingredient. However, Indonesia does not produce wheat domestically, so muffin consumption affects the level of importing wheat in Indonesia. Substitution of wheat flour by using local food such as *beneng* taro flour can be used as an alternative. Another local plant that has diverse nutritional content so that it can be utilized in making muffins is moringa leaves. One of the process conditions that need to be considered in making muffins is the baking time. This study aimed to determine the effect of composite flour formulation based on *beneng* taro and moringa leaf flour with variations in baking time on the nutritional value and sensory characteristics of muffins. This research used randomized complete factorial design with the treatment of variation of composite flour (80% wheat flour: 20% *beneng* taro flour) and moringa leaf flour (100%:0%, 97%:3%, 94%:6%, 91%:9%, and 88%:12%) called as (F1, F2, F3, F4, and F5) and baking times (25 and 30 minutes) called as (W1 and W2). The results showed that the addition of moringa flour increased the moisture, ash, protein, fat, carbohydrate content, but decreased the organoleptic acceptance of color, taste, aroma and overall, while baking time decreased moisture-content and organoleptic acceptance of color but increased acceptance of texture. These results provide new insights for improving nutritional content of muffin from moringa flour as a functional ingredient.

KEY WORDS
Baking time, formulation, moringa leaves flour, muffin, taro beneng flour.

Muffins are one of the popular and popular bakery products that are prepared by baking so that they have the characteristics of a cracked shape on the top surface, a golden yellow color, and a dense texture on the inside (Rosmania, 2013). The popularity of muffins is in line with the increase in participation in consumption of bakery products in the form of sweet bread and other breads in Indonesia, namely from 2016 by 53.95% to 60.96% in 2021 (BPS 2017; BPS 2021). Muffins are generally made using wheat flour as the main raw material. However, Indonesia is not a wheat producing country, so the higher consumption of muffins influences the high level of wheat imports in Indonesia. The level of wheat imports in Indonesia has increased from 10.083 million tons in 2018 to 11.172 million tons in 2021 (BPS, 2022).

One alternative for reducing the use of wheat flour in making muffins is to replace some of the wheat flour by using local food-based carbohydrate sources such as taro *beneng*. *Beneng* taro (Xanthosoma undipes K. Koch) is a local commodity originating from Pandeglang Regency, Banten Province. The use of *beneng* taro in society is still low, usually only consumed as a snack in the form of chips (Hidayat et al., 2022). Processing *beneng* taro tubers into flour is an effort to increase the shelf life and consumption of *beneng* taro. *Beneng* taro flour contains 84.10% carbohydrates; dietary fiber 9.52%; water 7.54%; protein 4.55%; ash 3.43%; fat 0.45%; vitamin E and several types of minerals such as Fe and Ca (Putri et al., 2021; Kusumasari et al., 2022). The nutrients contained make taro *beneng* flour have potential, one of which is as a mixture for composite flour in making food products. Composite flour is flour that consists of several types of raw materials such as tubers, nuts, or cereals with or without wheat or wheat flour and is used as raw material for processing several food products such as bakery and extrusion (Widowati, 2009 in Astuti, 2014).

Another local plant that has the potential to be utilized is moringa. Moringa (Moringa oleifera) can be found as a plant that grows on fences (Syamra and Indrawati, 2018). The use of Moringa leaves in society is only limited to complementing daily cooking, even only as animal feed (Isnan and Muin, 2017). According to Srimiati and Agestika (2022), making Moringa leaf flour is an alternative to extend shelf life and simplify the distribution process. Moringa leaf flour contains 47.96% carbohydrate content; dietary fiber 35.34%; protein 27.27%; ash 10.53%; fat 7.28%; and water 6.96%, calcium 929.29 mg/100 g; Fe 9.99 mg/100 g; Zn 2.32 mg/100 g; and vitamin E 113 mg/100 g (Yunita et al., 2022; Irwan, 2020; Misrawati and Marliah, 2021). The high nutritional value of Moringa leaf flour has the potential to increase the nutritional value of food products when used as a substituent.

Various studies have been carried out regarding the use of local food in making muffins. The addition of 12% Moringa leaf flour in making muffins can increase the iron content from 2.65 mg/100g to 3.55 mg/100g and the calcium content from 26.22 mg/100g to 55.06 mg/100g (Srinivasamurthy et al., 2017). The addition of 20% taro *beneng* flour in making muffins received the highest score in terms of taste acceptance compared to the addition of other concentrations of taro *beneng* flour (Nurtiana et al., 2022). Muffins made from 100% pumpkin flour can increase the food fiber content from 1.63 g/100g to 27.06 g/100g (Rismaya, 2016). Adding 50% yellow sweet potato flour to muffins can increase the carbohydrate content by 5.50% and protein by 4.77% (Hardiyanti, 2018).

One of the process conditions that need to be considered when making muffin products is the baking time. Making biscuits with variations in temperature and baking time shows that baking time can affect product quality such as nutritional value which includes carbohydrate, protein, fat and ash levels (Bahrein et al., 2021). In making snack food bars with variations in temperature and baking time, the longer the baking results in decreased sensory acceptance in the form of color and aroma but increases sensory acceptance in the form of texture (Kasim et al., 2018). There has been a lot of research related to making muffins with various types of flour. However, research into making muffins using local food in the form of *beneng* taro and moringa leaves with different baking times has never been carried out. Therefore, research on the formulation of composite flour based on *beneng* taro and moringa leaf flour in making muffins combined with baking time needs to be carried out as an effort to increase the use of local food and enrich the nutritional value of muffins and be sensory acceptable to the community.

METHODS OF RESEARCH

The equipment used in the research included a furnace (Nabertherm), a moisture oven (Memmert, UN55), a fume hood (Bio Chamb), a heating mantle (B-one), an analytical balance (Excellent, H7K), a Soxhlet apparatus and a Kjeldahl apparatus. The materials used in this research included H_2SO_4 (Merck), $CuSO_4$ (Merck), boric acid (Merck), methyl red indicator (Rofa), NaOH (Merck), hexane (Merck), distilled water and filter paper.

The moringa leaves used in making this flour were obtained from the plantation area of Kampung Solear RT 011 RW 002, Sukarame Village, Cikeusal, Serang, Banten, Indonesia with a plant age of 36 months. The Moringa leaves that have been sorted are then washed using running water until they are separated from the dirt. Moringa leaves that have been washed are then blanched using the water method, then dried using a cabinet dryer at 45˚C for 6 hours to produce dry moringa leaves. The dried moringa leaves are then crushed using a grinder, then sifted using a 100-mesh sieve to produce moringa leaf flour.

The flour used in making these muffins consists of two types of flour. The first flour is composite flour made from 80% wheat flour and 20% *beneng* taro flour, and the next flour is moringa leaf flour. Based on muffin formula in Table 1, for making 1726 g of muffin dough, composite flour and Moringa leaf flour totaling 525 g were mixed then added with 345 g of margarine which had been melted with 163 g of water and 3 g of salt (Mixing 1). The results of the first stage of mixing are then mixed with 300 g of eggs (Mixing 2). The results of the mixing in the second stage are then mixed with other ingredients in the form of 380 g of powdered sugar and 2 g of baking powder (Mixing 3). Muffin dough is produced after these three mixing stages. The resulting muffin dough is then put into a paper cup cake, and then baked at a temperature of 180℃ and time according to the treatment (Table 2).

Table 1 – Control muffin formula and moringa muffin formulation

Ingredient (g)	F1	F2	F3	F4	F5
Composite flour (20% *Beneng* taro flour: 80% wheat flour)	525	509.25	493.5	477.75	462
Moringa leaf flour	-	15.75	31.50	47.25	63
Margarine	345	345	345	345	345
Water	163	163	163	163	163
Salt	3	3	3	3	3
Egg	300	300	300	300	300
Fine granulated sugar	380	380	380	380	380
Baking powder	2	2	2	2	2

Note: F1 = composite flour 100%: moringa leaf flour 0%, F2 = composite flour 97%: moringa leaf flour 3%, F3 = composite flour 94%: moringa leaf flour 6%, F4 = composite flour 91%: moringa leaf flour 9%, and F5 = composite flour 88%: moringa leaf flour 12%.

Table 2 – Muffin baking process conditions

Parameter	Baking Process Conditions	
	W1	W2
Temperature (ºC)	180	180
Baking time (minutes)	25	30

Note: W1= baking time 25 minutes, W2= baking time 30 minutes.

The research design used was a factorial Completely Randomized Design (CRD) consisting of 2 factors. The first factor is the composite flour (20% *beneng* taro flour: 80% wheat flour) and moringa leaf flour which consists of 5 levels, namely F1 (100%:0%); F2 (97%:3%); F3 (94%:6%); F4 (91%:9%); and F5 (88%:12%). The second factor is baking time which consists of 2 levels, namely W1 = 25 minutes, and W2 = 30 minutes.

The weight of the cup is constant before use. As much as 2 g of sample are then weighed into a cup. The sample in the cup was dried until the weight was constant, then cooled in a desiccator for 30 minutes. The weight of the dry sample obtained was then calculated for its water content. Water content can be calculated using Equation (1), where W = initial sample weight (g), W1 = sample and cup weight was constant (g), W2 = weight of empty cup (g).

$$\text{Water content} = \frac{W-(W1-W2)}{W} \text{ X } 100\% \quad (1)$$

The weight of the porcelain cup is constant first. A sample of 2 g was weighed into a porcelain cup then burned in a furnace using a temperature of 600℃ for 1 hour. The sample in the cup has been burned and then cooled in a desiccator. The sample in the cup is then weighed until it remains constant, then the percentage of ash content is calculated using Equation (2), where W1=initial mop (g), W1 = sample and cup weight was constant (g), W2 = weight of empty cup (g).

$$\text{Ash content (\%)} = \frac{W3-W1}{W2} \text{ x } 100\% \quad (2)$$

The protein content test using the Kjeldahl method consists of 3 stages, the first stage is digestion, where 0.5 g of sample is put into a Kjeldahl flask and 3-5 g of catalyst ($CuSO_4$ and K_2SO_4) are added. A total of 7 mL of concentrated H_2SO_4 was added to the Kjeldahl flask containing the sample (carried out in an acid chamber), then the boiling stone was inserted into the Kjeldahl flask. The sample that had been mixed with the catalyst and concentrated H_2SO_4 was then digested in an acid chamber using a temperature of 420˚C until the color was clear green, then cooled and diluted using 50 mL of distilled water.

The second stage is distillation, where the entire sample is transferred into a Kjeldahl flask and the distillate container is prepared in an Erlenmeyer flask in the form of 10 mL of 2% boric acid, then 3 drops of methyl red indicator are added. Into the Kjeldahl flask then put 40 mL of 40% NaOH and a boiling stone, and immediately cover. Distillation is carried out until all NH_3 is collected, around 50-75 mL, which produces a yellow color. The third stage is titration, the collected distillate is titrated with 0.2 N HCl which has been standardized using sodium carbonate until a red color is formed. Protein levels in samples are calculated by Equation (3) and Equation (4), where Vp = Nitration volume of 0.2 N HCl solution (mL), Np = Normality of 0.2 N HCl solution, FK = Protein conversion factor.

$$\text{Protein weight (g)} = \frac{\text{Vp x Np x fk x 14,007}}{1000} \quad (3)$$

$$\text{Protein content (\%)} = \frac{\text{protein weight (g)}}{\text{Sample weight (g)}} \text{ x } 100\% \quad (4)$$

The weight of the round bottom flask was kept constant. The sample weighed 2 g, then put into filter paper that had been shaped into a circle. The filter paper that has been filled with the sample is inserted into the Soxhlet apparatus and a condenser is installed at the top, then connected to a water hose. Hexane was added to soak the sample. Extraction is carried out for 3-6 hours (around 5-6 circulations) or until no fat is extracted. Hexane is distilled until the hexane in the Soxhlet is used up. The fat that has been extracted from the pumpkin is then placed in a 105℃ oven for 30-60 minutes (until all the hexane has evaporated). The dried pumpkin is then cooled in a desiccator. The fat pumpkin was weighed until constant. Fat content can be calculated using Equation (5), where W = sample weight (g), W1 = pumpkin weight + constant fat (g), W2 = constant empty flask weight (g).

$$\text{Fat content (\%)} = \frac{W1-W2}{W}\ x\ 100\% \quad (5)$$

Carbohydrate content of muffin can be calculated using the Equation (6).

$$\text{\% Carbohydrate content} = 100\% - \%\,water\ content + \%\,ash\ content + \%\,fat\ content + \%\,protein\ content \quad (6)$$

Organoleptic analysis in this study used the balanced incomplete block designs (BIBD) technique as an effort to minimize the number of samples tested for each panelist (Rismaya, 2016). Organoleptic analysis was carried out on students of the Food Technology study program with an age range of 19-22 years. Organoleptic analysis of muffin samples includes color, aroma, taste, texture, and overall parameters. In this organoleptic analysis, a score of 1 to 7 is used with the criteria: very dislike (1), dislike (2), somewhat dislike (3), neutral (4), somewhat like (5), like (6), and very like (7). Each panelist assesses each sample based on everyone's preferences using the numerical score for each parameter.

The data was statistically analyzed using T-test analysis and one-way ANOVA. If the results of the analysis of variance show that the factors have a significant effect, then a Duncan Multiple Range Test is performed to determine the difference in the average measurement results between treatments at the confidence level α=0.05. If the interaction of the two factors has a significant effect on the response, Estimated Marginal Means is performed via the Syntax General Linear Model to see the effect of the simple effect. Data were analyzed statistically using SPSS 21 (IBM SPSS version 21.0, SPPS Inc., Chicago).

RESULTS AND DISCUSSION

Along with the addition of Moringa leaf flour in making muffins, it plays a role in increasing the water content of the muffins produced. Water in food can be found between cells, trapped in cells, or bound to a chemical compound in food (Kusnandar, 2020). Therefore, the water content in food products such as muffins can be influenced by the presence of compounds that have the characteristics of being able to bind water such as dietary fiber and starch. Dietary fiber has a high ability to bind water, where the ability of fiber is greater than starch to hold water (Schleißinger et al., 2013). The water holding capacity of fiber is 3.6 g/g while that of starch is only less than 1.0 g/g (Triwitono et al., 1999; Rahim et al., 2017). The water content in the muffins increased along with the addition of Moringa leaf flour, presumably because of the high dietary fiber content in Moringa leaf flour. High dietary fiber content in food can increase the amount of bound water in food products (Rismaya, 2016). The addition of Moringa leaf flour in making muffins can increase the level of dietary fiber which results in more water content being bound to the muffins produced.

Table 3 – Response of formulation and baking time to water content in muffins

Formula	Baking Time (Minutes)		Average (%)
	25 (W1)	30 (W2)	
F1	15,89±0,52	12,64±3,93	14,27^{A}
F2	17,74±3,42	13,90±2,97	15,82^{AB}
F3	20,43±0,45	17,76±1,96	19,10^{BC}
F4	20,21±2,02	19,91±2,76	20,07^{C}
F5	22,86±3,62	19,70±0,23	21,28^{C}
Average (%)	19,43^{Z}	16,79^{Y}	18,11

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%. Numbers followed by the same letter in a column are not significantly different at the 5% significance level. The letters ABCDE indicate the influence of composite flour formulation factors based on beneng taro flour and moringa leaf flour (F). The letter YZ indicates the influence of the baking time factor (W).

Based on Table 3, the water content decreases as the baking time increases. The decrease in water content during the baking process is caused by heat transfer through the baking tool which causes the water contained in the product to evaporate (Veronika et al., 2019). The longer the baking time causes the muffins to be in contact with the baking tool for longer so that more water evaporates, and these results in a decrease in the water content of the muffins.

The ash content of a sample shows the total minerals contained in the sample. Ash content analysis is very important to carry out because it is an effort to determine the nutritional quality of an ingredient or food product and can be used as basic data for processing which in some foods can be influenced by the presence of these minerals (Andarwulan, 2011). The ash content increased with the addition of Moringa leaf flour. The various mineral content in Moringa leaf flour is one of the factors that causes an increase in the ash content in muffins. The mineral content of dried Moringa leaves includes 3.65% calcium, 0.3% phosphorus, 0.5% magnesium, 1.5% potassium, 0.164% sodium, 0.63% sulfur, 13.03 mg/kg zinc, copper 8.25%, manganese 86.8 mg/kg, iron 490 mg/kg, and selenium 363 mg/kg (Moyo et al., 2011).

Table 4 – Response of formulation and baking time to ash content in muffins

Formula	Baking Time (Minutes)		Average (%)
	25 (W1)	30 (W2)	
F1	0,44±0,08	0,46±0,02	0,45^{A}
F2	0,46±0,19	0,57±0,18	0,52^{A}
F3	0,58±0,05	0,95±0,06	0,76^{B}
F4	0,65±0,16	0,96±0,18	0,80^{BC}
F5	1,09±0,08	0,94±0,03	1,02^{C}
Average (%)	0,62	0,78	0,71

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%. Numbers followed by the same letter in a column are not significantly different at the 5% significance level. The letters ABCDE indicate the influence of composite flour formulation factors based on beneng taro flour and moringa leaf flour (F).

Based on Table 4, baking time has no significant effect on ash content. This is in accordance with research by Sarofa et al. (2020), where the drying time treatment for spice powder did not have a significant effect on the ash content. Although some components in food can be damaged through the heating process, this process does not significantly affect the mineral levels contained in food products (Sarofa et al., 2020).

Proteins are polypeptide molecules with a large size and are composed of more than 100 amino acids linked to each other through covalent bonds in a unique sequence called peptide bonds (Andarwulan, 2011). Protein content tended to increase with increasing moringa leaf flour and decreasing *beneng* taro composite flour. This is because *beneng* taro flour has a protein content of 5.42% (Hidayat et al., 2022). According to Helmiati et al. (2020), Moringa leaf flour has a protein content of 25.77%, so when compared with the protein content of taro *beneng* flour, Moringa leaf flour has higher protein. Therefore, adding Moringa leaf flour in making muffins can increase the protein content in the muffins produced.

Table 5 – Response of formulation and baking time to protein content in muffins

Formula	Baking Time (Minutes)		Average (%)
	25 (W1)	30 (W2)	
F1	4,37±0,02	4,73±0,39	4,55^{A}
F2	4,74±0,39	4,80±0,13	4,77^{A}
F3	5,19±0,08	4,67±0,04	4,93^{AB}
F4	5,27±0,00	4,57±0,01	4,92^{AB}
F5	5,50±0,01	5,13±0,51	5,31^{B}
Average (%)	5,01	4,78	4,90

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%. Numbers followed by the same letter in a column are not significantly different at the 5% significance level. The letters ABCDE indicate the influence of composite flour formulation factors based on beneng taro flour and moringa leaf flour (F).

Based on Table 5, baking time did not show a significant effect on protein content. Heating is one of the factors that causes proteins to denature (Arora et al., 2022). However, protein denaturation only changes the secondary, tertiary, and quaternary structure of the protein without causing changes to the amino acid sequence in the protein structure (Kusnandar, 2020). Therefore, the baking time will not change the protein content contained in the muffins.

Fat is a nonpolar ester compound which is insoluble in water. In food, fat plays a role in determining overall physical characteristics such as aroma, texture, taste and appearance (Angelia, 2016). Analysis of fat content in food products can provide information that can be applied to various needs (Andarwulan, 2011).

Table 6 – Response of formulation and baking time to fat content in muffins

Formula	Baking Time (Minutes)		Average (%)
	25 (W1)	30 (W2)	
F1	23,14±0,11	22,03±3,81	22,59^{A}
F2	24,76±1,57	24,65±0,47	24,71^{AB}
F3	26,63±1,83	26,69±3,01	26,66^{BC}
F4	27,21±0,77	26,42±1,01	26,82^{BC}
F5	28,65±0,83	28,56±2,90	28,60^{C}
Average (%)	26,08	25,67	25,88

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%. Numbers followed by the same letter in a column are not significantly different at the 5% significance level. The letters ABCDE indicate the influence of composite flour formulation factors based on beneng taro flour and moringa leaf flour (F).

Based on Table 6, fat content increased with the addition of moringa leaf flour and reduction of *beneng* taro composite flour. The fat content in Moringa leaf flour is known to be 4.8%, while in taro *beneng* flour it is only 0.6% (Helmiati et al., 2020; Hidayat et al., 2020). Therefore, the addition of Moringa leaf flour along with the reduction of taro *beneng* composite flour in making muffins is thought to play a role in increasing the fat content.

Baking time did not show a significant effect on fat content. The heating process for five minutes still cannot reduce the fat content significantly because the heating time does not change the structure of the fat or its micromolecular derivatives too much (Jacoeb et al., 2018). According to Sturzenegger and Sturm (1951), fat hydrolysis occurs at a temperature of 220℃, while muffin baking in this study used a temperature of 180℃. Therefore, the baking time will not affect the fat content of the muffin because the fat contained has not been hydrolyzed at a temperature of 180℃.

Carbohydrates are compounds composed of carbon, hydrogen and oxygen with the general molecular formula Cx(H2O)y. Carbohydrates have functional properties so they can play a role as an important ingredient in every food processing process. In food, carbohydrates can be used as fillers, stabilizers, thickeners, sweeteners, gel and film formers, as well as fat replacers (Kusnandar, 2020).

Table 7 – Response of formulation and baking time to carbohydrate content in muffins

Formula	Baking Time (Minutes)		Average (%)
	25 (W1)	30 (W2)	
F1	56,17±0,70	60,15±7,35	58,16^{B}
F2	52,30±2,45	56,08±3,35	54,20^{B}
F3	47,17±1,25	49,92±4,95	48,56^{B}
F4	46,66±1,04	48,18±3,57	47,40^{A}
F5	41,90±2,69	45,67±2,18	43,78^{A}
Average (%)	48,84	51,99	50,44

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%. Numbers followed by the same letter in a column are not significantly different at the 5% significance level. The letters ABCDE indicate the influence of composite flour formulation factors based on beneng taro flour and moringa leaf flour (F).

Based on Table 7, the higher the addition of Moringa leaf flour causes a decrease in carbohydrate levels in the muffins. This is thought to be related to the increase in water, ash, protein and fat content along with the addition of Moringa leaf flour so that in one serving of muffin there is a decrease in carbohydrate content. Baking time does not show a significant effect on carbohydrate content. Increasing the heating time for muffins can cause the starch contained to hydrolyze into a simpler form (Sari et al., 2018). However, simpler forms of carbohydrates will still count as crude carbohydrates.

Organoleptic analysis is an important stage to determine the level of consumer acceptance of a product (Munir et al., 2018). Organoleptic analysis of muffin samples includes color, aroma, taste, texture and overall parameters are presented in Table 8.

Table 8 – Organoleptic test results for muffins

Sample	Test Parameters				
	Color	Aroma	Taste	Texture	*Overall*
F1W1	5,67±0,71^{D}	5,78±0,83^{C}	5,44±1,01^{BC}	4,67±1,73^{BC}	5,33± 1,12^{CD}
F2W1	3,67±1,32^{B}	3,89±1,27^{AB}	4,56±1,74^{AB}	4,56±1,24^{ABC}	4,44±1,24^{BC}
F3W1	4,00±1,80^{BC}	4,56±1,94^{B}	4,56±1,67^{AB}	4,78±1,09^{BC}	4,67±1,50^{BC}
F4W1	3,22±1,30^{AB}	4,00±1,41^{AB}	4,00±1,41^{A}	3,89±1,54^{AB}	3,89±1,76^{AB}
F5W1	2,33±0,87^{A}	3,11±1,62^{A}	3,67±1,32^{A}	3,33±1,00^{A}	3,11±1,27^{A}
F1W2	5,78±0,97^{D}	6,11±0,60^{C}	6,33±0,50^{C}	5,33±1,32^{C}	6,00±0,71^{D}
F2W2	5,00±1,41^{CD}	4,00±1,00^{AB}	4,44±0,88^{AB}	4,56±1,01^{ABC}	4,56±1,01^{BC}
F3W2	4,33±0,87^{BC}	3,33±0,71^{AB}	4,11±1,36^{A}	4,56±1,33^{ABC}	4,11±1,05^{ABC}
F4W2	3,78±1,39^{BC}	4,22±0,97^{AB}	4,00±0,87^{A}	5,11±0,93^{BC}	4,56±0,88^{BC}
F5W2	3,33±1,50^{AB}	3,67±1,10^{AB}	4,33±0,70^{AB}	4,44±0,70^{ABC}	4,22±0,80^{ABC}

Note: F1= composite flour 100%: moringa leaf flour 0%, F2= composite flour 97%: moringa leaf flour 3%, F3= composite flour 94%: moringa leaf flour 6%, F4= composite flour 91%: moringa leaf flour 9%, and F5= composite flour 88%: moringa leaf flour 12%, W1= baking time 25 minutes, W2= baking time 30 minutes. Different letter notation in a Colom shows a significant difference (p<0.05).

Color acceptability decreased with the increase in moringa leaf flour in the muffins and the reduction in *beneng* taro composite flour. The decreased color acceptance is thought to be because the green color of the muffins due to the presence of chlorophyll pigment is an unusual color in muffin products so that consumer acceptance is quite low for muffins added with Moringa leaf flour. Color acceptability also decreased with increasing baking time. This is thought to be because the increase in baking time causes the crust of the muffin to have a darker color, so the panelists' acceptance is lower. The dark color can be caused by the Maillard reaction that occurs during the baking process. The Maillard reaction consists of several stages, namely the condensation stage, the amadori rearrangement stage and the polymerization stage. According to Kusnandar (2020), the formation of a dark brown color in the form of melanoidin compounds occurs at the polymerization stage.

The aroma acceptance decreased with the addition of Moringa leaf flour in muffin products. This can be caused by the unpleasant aroma contained in Moringa leaf flour. Moringa leaves contain essential oils and lipoxidase enzymes which cause a pleasant aroma (Helingo et al., 2021). Apart from that, Moringa leaves contain saponin compounds which also cause a pleasant aroma (Rustamaji and Ismawati, 2021). In Moringa leaves there are as many as 93 types of volatiles consisting of aldehydes, ketones, hydrocarbon esters, terpenoids and acids (Mukunzi et al., 2011). Some volatile compounds such as aldehydes, ketones and terpenoids do not decrease with the length of heating provided (Lomelí-Martín et al., 2021). Some volatile compounds are not degraded due to the heating process.

The resulting data shows that the addition of Moringa leaf flour causes the taste acceptability of the muffins to decrease. The higher concentration of Moringa leaf extract flour causes the appearance of a bitter and bitter taste in the product which is caused by the presence of saponin (Indriasari et al., 2019). Baking time did not show a significant effect on the taste acceptability of the muffins. According to Wong et al. (2008), amino acids found in food are one of the factors that can significantly improve the taste of food products because they can influence the formation of flavor compounds. Flavor compounds can be formed through the Maillard reaction at the rearrangement stage and are influenced by heating. Even though it is influenced by the heating process, the formation of these flavor compounds needs to be supported by the availability of amino acid groups because they are one of the compounds that react with reducing sugars (Kusnandar, 2020).

The texture of muffins can be influenced, among other things, by the presence of gluten. Gluten is a type of protein contained in wheat flour which provides elasticity to the dough, helps the dough rise and maintain its shape and gives the final product a chewy texture (Kumar, 2014). The addition of Moringa leaf flour and *beneng* taro flour in the composite flour contributes to reducing the amount of gluten in the muffins, so that the texture of the muffins tends to be harder. Baking is one of the important parameters that needs to be considered in developing gluten structure. The baking process causes the gluten to harden and provides structure to the bread (Kumar, 2014).

Overall acceptance decreased with the addition of Moringa leaf flour in the muffins. This is because the addition of Moringa leaf flour tends to reduce the acceptability of color, aroma and taste in muffins. The color acceptance decreased because the addition of Moringa leaf flour made the resulting muffins darker. The aroma acceptance decreases due to the content of essential oils, lipoxidase enzymes and saponins which make the muffin aroma pleasant. The taste acceptance decreased because the addition of Moringa leaf flour made the muffin taste more bitter and bitter due to the saponin content. Therefore, a decrease in acceptance of these parameters can affect the overall decrease in acceptance of the muffin products produced. The overall average acceptance for muffins with variations in baking time was 4.29 (neutral) to 4.69 (neutral). This can be influenced by the perceived color, taste and aroma which are not significantly different in muffins with variations in baking.

CONCLUSION

The addition of Moringa leaf flour in making muffins can increase the nutritional value of the muffins produced but tends to reduce sensory acceptance. Baking time does not have a significant effect on ash content, protein content, fat content and carbohydrate content but does have a significant effect on water content.

ACKNOWLEGMENTS

The authors would like to thank the Institute for Research and Community Service (LPPM), University of Tebuka, for providing financial support.

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