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Physico-Chemical Properties of Corn Bread Fortified with Moringa Leaves (*Moringa oleifera*) Flour

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ABSTRACT

This study aimed to examine the effect of Moringa leaf flour concentration on the physical and chemical properties and level of preference of Moringa corn bread. The study was conducted with variations of Moringa leaf flour concentration (TK): TK1 = 1%; TK2 = 3%; TK3 = 5%; TK4 = 7%. Parameters to be analyzed included physical properties, namely bread volume, specific volume of bread and bread elasticity. Chemical properties included water content, protein, vitamin C, β-karoten. The results showed that the highest macro- and micronutrient values in the addition of 7% Moringa leaf flour was inversely proportional to the physical properties of the bread, namely a decrease in the specific volume and elasticity of Moringa cornbread which resulted in a decrease in panelists' acceptance of Moringa cornbread products. TK3 was the best with protein value of 7.27 mg/100g, vitamin C 60.0 mg/100g, β-karoten 13909.99 µg/100g, specific volume of bread 3.71 cm^3/g and bread elasticity of 75.14% and the highest sensory acceptance of moringa cornbread.

1. INTRODUCTION

Efforts to diversify or substitute the use of corn flour in bread making are opportunities that need to be continuously studied to reduce dependence on wheat flour. The results of research on the use of corn flour in the process of making bread products show that with the addition of 50% modified corn flour as a substitute for wheat, the specific volume of bread is 1.61 - 1.96 cm^3/gr and the volume of bread produced is close to that of wheat flour and the composition of the bread. better chemical, bread quality, and functional properties (Richana *et al*., 2010).

This corn bread product is expected to provide an alternative to healthy and nutritious fibrous food for consumers as well as for diabetics. However, the problem with corn bread is that there are deficiencies of several micronutrients such as vitamins A, B, and C. This can be overcome by improving the process of making corn flour and fortification or

supplementation with other ingredients in making bread. Regarding the improvement of the process of making corn flour, the results of research by Aini *et al*., (2016) showed that corn flour that had the best functional properties was corn flour which was produced by fermentation method using Lactobacillus casei for 60 hours. The research of Medho *et al*. (2018) regarding the chemical properties of modified flour from local white corn, the best conditions were with 36 hours of fermentation with a lactobacillus casei concentration of 2% with a total protein value of 8.66% and a total acid value of 0.41%. Related to fortification with other ingredients in making bread, the results of research by Sugiharto & Ayustaningwarno (2014) show that sweet bread substituted with 20% spirulina flour is an alternative food supplement that is rich in protein, vitamin A, and iron. Apart from spirulina leaves, there are other local specific materials that have the potential to be used, for example, moringa leaves.

Moringa plants (*Moringa oleifera*) are easy to grow in tropical and subtropical areas and are resistant to drought for up to 6 months, such as in several areas in Indonesia, including the Province of East Nusa Tenggara. People use moringa leaves as food and medicine because according to Offor *et al*. (2014) there are approximately 300 diseases that can be cured when consuming moringa leaves and seeds. As a food source, moringa leaves also contain elements of micronutrients that are needed by pregnant women, such as b-Carotene, Thiamin (B1) Riboflavin (B2) and niacin (B3), calcium, iron, phosphorus, magnesium, zinc, vitamin C. Moringa leaves are also good as an alternative to improve the nutritional status of pregnant women.

The fulfillment of nutritional needs derived from moringa can be done by consuming moringa in various servings, namely vegetables, snacks, pharmaceutical products (capsules, tablets, oil) and stock in the form of flour. Moringa flour is a product obtained by blanching at 80 °C for 3 minutes to prevent the smell and aroma of raw moringa, then drying and flouring with a size of 80 mesh (Medho & Muhamad, 2019). In addition to eliminating odors and aromas, steam blanching can also increase digestibility and produce the highest amino acid content of 31.49% (Kirana *et al*., 2013). Meanwhile, the highest β-Carotene content of moringa leaves flour was obtained in the steamed blanching treatment, which was 35.55 mg and the lowest β-Carotene content was in the boiled blanching treatment, which was 20.01 mg, while the β-Carotene content without blanching was 26.91 mg (Zakaria *et al*., 2015). The results of Zakaria *et al*. (2012) showed that every 100 grams of moringa leaves flour has a protein content of 28.25% so that moringa is classified as an alternative food to overcome nutritional problems (malnutrition).

The addition of moringa leaf flour as a fortification ingredient in addition to increasing the nutritional value also affects the sensory value of food products, especially the taste, aroma and texture of the product. Research by Cengceng *et al*. (2020) showed that the Fe content in white bread without the addition of moringa leaves flour was 0.79% and the Fe content increased after the addition of 12% moringa leaf flour which was 4.91% as well as the antioxidant activity increased with a value of 35,006 g/mL (very strong), but the organoleptic values for all attributes were preferred with the addition of 4% moringa leaf flour. The research of Helingo *et al*. (2021) found that the addition of 7% moringa leaves flour in the manufacture of sweet bread made from breadfruit flour caused the protein content to increase with a value of 29.42%, but the swelling ability of bread decreased with the higher concentration of moringa. Based on these problems, our current research is directed to the use of corn flour which has minimal micronutrients as a substitute for wheat flour and moringa leaves flour as a fortificant to provide adequate nutrition in corn bread products and to

examine the effect of the concentration of moringa leaves flour on the physical, chemical and sensory properties of moringa-corn bread. Specifically, the purpose of this study was to examine the effect of the concentration of addition of moringa flour on the physical and chemical properties and level of preference of moringa-corn bread.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study included local Timor white corn flour fermented with tape yeast and moringa leaves flour produced by the Production House of the Department of Dry Land Agricultural Management. This material will be used as the main raw material in this research. Other additives for making bread are wheat flour (hard flour), water, butter, salt, eggs, milk, sugar, yeast. The material for testing the volume of bread is grain. The main tools for making corn flour and moringa leaves flour as well as making bread are mortar and pestle, fermentation jar, grinder, sieve, dough mixer and oven. The tools for testing the bread volume and elasticity of cornbread are a glass beaker, ruler, and caliper.

2.2. Moringa Leaves Flour Preparation

The manufacture of moringa leaves flour follows the research procedure of Medho & Muhamad (2019). Moringa leaves were taken based on their position in 1 (one) branch of the tree branch and taken on leaf sections number 2, 3, and 4 from the shoot. Then the leaves were cleaned from the stalks and then blanched at 80 ^{o}C with a blanching time of 3 minutes. The next stage is dried in full sun for 4 hours. After drying, the moringa leaves were ground using a stainless steel flouring machine, then sieved using an 80 mesh sieve and packaged in aluminum foil, then put in a watertight plastic container and stored at room temperature.

2.2. Fermented Corn flour preparation

The manufacture of modified corn flour by fermentation follows the research results of Medho *et al*. (2018). The corn used is local Timorese white corn which has a white color, so if it is used for application it is expected to have physical properties, especially the color similar to wheat flour. The selection of the type of microorganism followed the research of Richana *et al*. (2010) namely tape yeast. The shelled corn is grinded manually using a masher by adding water little by little until the husk is peeled off then cleaned using a winnowing tool and then dried. The next step is that the corn is fermented in a fermentation medium where the ratio of water to corn is 2:1. Tape yeast was added as much as 2 g/kg corn and the fermentation time was 24 hours. After the fermentation stage, the corn is then drained and dried. Drying is carried out in a drying oven at a temperature of 60 °C with a time of 8 hours or 12 hours when drying in the sun. The next stage is corn milling and sifting using an 80 mesh sieve then packaged in plastic then put in a watertight plastic container and stored at room temperature.

2.3. Moringa-Corn Bread Preparation

Bread preparation follows the procedure for making sweet bread referring to Manfred Lange & Bogasari Baking Center (2006). Figure 1 presents the flow chart for making moringa-corn bread. The formulation as presented in Table 1.

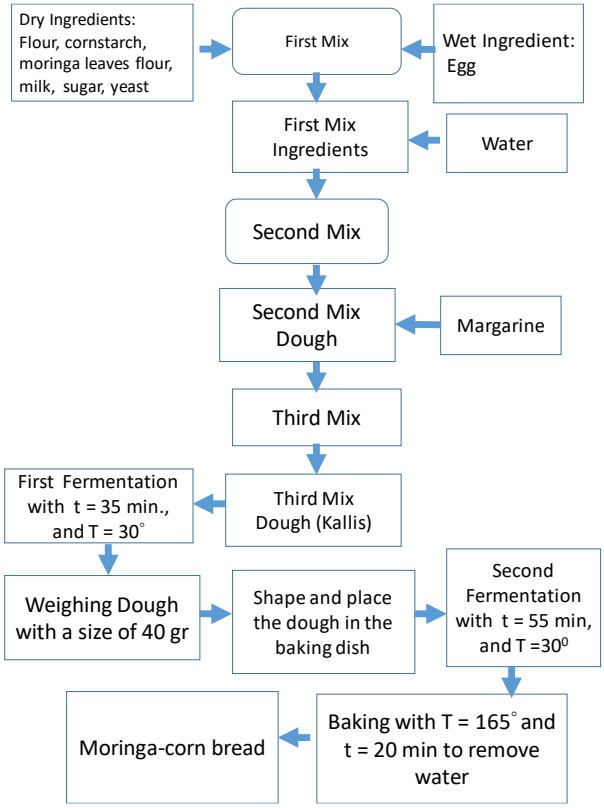

Figure 1. Flowchart of making moringa-corn bread

Table 1. Moringa-corn bread formulation

Flour types	Flour formulation (%)			
	F1	F3	F5	F7
Flours:				
Moringa leaves flour	1	3	5	7
Wheat flour	60	60	60	60
Modified corn flour	40	40	40	40
Atitives:				
Yeast	2.2	2.2	2.2	2.2
Sugar	15	15	15	15
Butter	18	18	18	18
Milk powder	5.4	5.4	5.4	5.4
Water	45	45	45	45
Egg (unitless)	2	2	2	2

2.4. Experimental Design

This study was designed using a completely randomized design (CRD) with factors namely the concentration of moringa leaves flour (TK) where TK1 = 1 %; TK2 = 3%; TK3 = 5%; and TK4 = 7%. Each treatment was repeated 5 times so that 20 experimental units were obtained. Observational data were analyzed by analysis of variance at a significance level of 5% using Co-Stat software. If there is a significant difference, further testing is carried out using Duncan Multiple Range Test (DMRT) for all

parameters at the same significant level. Variables observed included chemical test of moringa-corn bread, namely: moisture content by drying method (AOAC, 2007), total protein content by micro Kjeldahl method (AOAC, 2007), Vitamin C and β-Carotene.

2.5. Bread Physical Properties

The physical test of bread includes the volume of bread expansion, the specific volume of the bread and the elasticity of the bread. Determination of bread elasticity during the shelf life was carried out based on the method of Lazaridou *et al*. (2007). Bread is cut to a thickness of 3 cm from the bottom (t_1). The top surface of the bread is then pressed with a beaker glass to half of its original height (1.5 cm) for 1 minute. After 1 minute the bread was removed and the bread thickness was measured (t_2). The elasticity of the bread is calculated by the following equation:

$$\text{Bread elasticity} = (t_2/t_1) \times 100\% \quad (1)$$

Bread volume was measured based on the method of Różyło *et al*. (2015). First, the bread sample was placed in a container with a known volume (*VC*). The container is then filled with rice grain, the bread is then removed and the volume of grain in the container is then measured (*VR*). The volume of bread (*VL*) is measured by the equation:

$$VL \text{ (ml)} = VC - VR \quad (2)$$

Specific volume (Vs) of bread was measured by cooling the bread for one hour and then measuring its weight *W* (g). After that, the specific volume of bread is calculated by the equation:

$$Vs \text{ (ml/g)} = VL/W \quad (3)$$

2.6. Hedonic Rating Test

Sensory test of cornbread fortified with moringa flour with the hedonic rating method (Meilgaard *et al*., 2007) to determine the best that can be accepted by consumers. Sensory testing is a hedonic test to determine the level of preference. The hedonic test carried out is rating. Parameters tested in the rating test include color, texture, taste, and overall. There are 7 levels of assessment score used, namely 7 = very much like, 6 = like, 5 = somewhat like, 4 = neutral, 3 = slightly dislike, 2 = dislike, and 1 = very dislike. The organoleptic assessment was carried out by 25 untrained panelists, namely lecturers, students aged 18-45 years. Furthermore, analysis of variance was carried out on the data from the sensory test results.

3. RESULTS AND DISCUSSION

3.1. Chemical Properties of Moringa-Corn Bread

Chemical properties of corn bread fortified with moringa leaves flour (TK) was carried out to see the effect of the concentration of moringa leaves flour on changes in water content, protein, micronutrients namely vitamin A, viatamin C, and β-Carotene. The results of chemical analysis and the average value of moisture content, protein and micronutrients of moringa-corn bread are presented in Table 2.

3.1.1. Water Content

The results of analysis of variance showed that the moisture content of moringa-corn bread at the concentration of moringa flour was not significantly different ($\alpha > 0.05$). Although not significantly different, it can be seen that the moisture content of

moringa-corn bread increased with the higher concentration of moringa flour. The water content was higher at 5% moringa concentration, which was 29.70% and decreased to 29.24% at the addition of moringa flour with concentration of 7%. The influencing factor is that the starch content is related to the water content. Moringa flour is different from other composite flours including corn flour with a higher starch content than moringa flour. Even though the addition of large amounts of moringa flour did not affect changes in water content because the starch content as a water-binding agent in moringa flour was very low. The water content produced in all treatments was still below SNI 01-3840-1995 (BSN, 1995) where the maximum water content in sweet bread was 40% (ww), so the moisture content of moringa corn bread in this study could still meet the requirements of SNI.

Table 2. The effect of moringa leaves flour addition of on changes in the nutritional value of moringa-corn bread

Moringa leaves flour addition	Changes on nutrition values of moringa-corn bread			
	Water content (%)	Protein (mg/100g)	Vitamin C (mg/100g)	β-Carotene (µg/100g)
TK1	29.3 a	6.89 b	37.5 c	764.58 a
TK2	29.48 a	6.95 b	42.3 c	8,062.44 b
TK3	29.70 a	7.27 ab	60.0 b	13,909.99 c
TK4	29.24 a	7.70 a	71.66 a	23,679.84 d

Note: Average values followed by with different lowercases mean significantly different at DMRT 5%.
TK1 = Moringa leaves flour consentration 1%
TK2 = Moringa leaves flour consentration 3%
TK3 = Moringa leaves flour consentration 5%
TK4 = Moringa leaves flour consentration 7%

3.1.2. Protein

According to some researchers, the protein in moringa leaves is quite high. As a comparison, Sugianto (2016) found that protein content based on leaf position, namely: moringa leaf shoots (young leaves) contain 39.00% (dw), middle leaves (middle age leaves) contain 26.96% (dw), and lower leaves (old leaves) contains 26.72% (dw). Research Dewi *et al*. (2015) stated that the addition of 5% moringa leaf flour in the manufacture of moringa cookies with a different roasting temperature treatment of 140°C obtained a protein content of 13.26% and decreased at a baking temperature of 160°C obtained 12.76%. During the roasting process, there is a decrease in water content of 70%-90%, protein content of 10%-15%, and ash and mineral content of 0.5%.

Table 2 shows that the more addition of moringa flour (TK), the higher the protein content of moringa-corn bread and a very significant effect is seen in each treatment. The protein content of the moringa-corn bread product with the concentration of moringa flour TK1 (1%) was lower that is 6.89% compared to the concentration of TK2 (3%) moringa flour which is 6.95% and the concentration of TK3 moringa flour (5%) which is 7.27% and the concentration of TK4 moringa flour (7%) which is 7.70%. This is because the higher the concentration of moringa flour, the higher the protein content because the protein contained in moringa flour is also high. As a comparison, Aryani *et al*. (2019) in the manufacture of white bread substituted with potato flour (700:300) or 30% potato flour with the addition of 3% moringa flour, the protein content is 7.27% with a roasting temperature of 190-200 °C. This protein content is the same as sweet bread substituted with 40% corn flour fortified with 5% moringa flour.

3.1.3. Vitamin C

The results of the analysis of variance showed that the vitamin C content of moringa-corn bread in the treatment of moringa flour concentrations was very significantly different (α > 0.01). From Table 2, it can be seen that the lowest vitamin C value in the addition of 1% moringa flour is 37.5 mg/100g and the highest vitamin C value in the addition of 7% moringa leaves flour is 71.66 mg/100g. This is due to the high content of vitamin C in moringa leaves with more and more moringa leaves flour being added to corn bread products.

The amount of vitamin C in moringa leaves flour in the Medho & Muhamad (2019) study by blanching moringa leaves for 3 minutes obtained the total vitamin C content in moringa flour as much as 33.63 mg/100g. A decrease in vitamin C will also definitely occur when roasting moringa corn bread with a roasting temperature of around 160 °C with a time of 20 minutes. As a comparison, work of Pangaribuan (2013) found the content of vitamin C in moringa leaves powder is 5.10 mg/10 g or 51.04 mg/100 g, whereas based on the results of preliminary research by Dewi *et al*. (2015) the levels of vitamin C in moringa leaves flour was 153.23 mg/100 ml. The decrease in vitamin C levels should have occurred during roasting, but it increased and was seen when baking moringa cookies with the addition of 3% moringa leaves flour at a baking temperature of 160 °C with 15 minutes of vitamin C content obtained 189.5 mg/100 ml. This is due to the more concentration of moringa leaves flour added, the higher the value of vitamin C in the cookies produced.

3.1.4. β-Carotene

Based on analysis of variance, it was shown that the β-Carotene content of moringa-corn bread at the concentration treatment of moringa leaves flour was very significantly different (α > 0.01). From Table 2 it can be seen that the more moringa leaves flour was added, the β-Carotene content of moringa-corn bread tended to increase significantly. Moringa leaves contain β-Carotene which is quite high. The results of the research by Medho & Muhamad (2019) found that the amount of β-Carotene in moringa leaves flour which underwent a 3-minute blanching process at 80 °C was 299.33 mg/100g. The content of β-Carotene should be reduced and damaged due to processing, especially by heating at high temperatures during baking. The results of this study indicate that the value of β-Carotene will increase along with the increase in the concentration of fortified moringa leaves on corn bread. This can be seen from the lowest value of β-Carotene, namely the addition of 1% moringa flour, which is 764.58 mg/100g and a significant increase in the addition of 7% moringa leaves flour, which is 23,679.84 mg/100 g. This is because the amount of moringa leaves flour added will increase β-Carotene levels in moringa-corn bread products. As a comparison in the research by Cahyaningati & Sulistiyati (2020), there was also an increase in β-Carotene in catfish meatballs with the addition of a concentration of 7.5% moringa leaves flour obtained β-Carotene of 7,607.67 mg and the lowest was in the treatment without the addition of moringa leaves (0%) with the value of β-Carotene was 143.87 mg. Chemically, the value of these micronutrients is very good when present in food, but the sensory value of these products also needs to be considered related to consumer preferences for color, texture, taste and aroma of products made from moringa.

3.2. Physical Properties of Moringa-Corn Bread

The physical properties of bread include the volume of bread and the specific volume of bread as well as the elasticity of the bread. The physical properties associated with

the use of wheat flour and other composite flours affect the final product produced. In making moringa-corn bread, the main ingredients are wheat flour, corn flour and the addition of moringa leaves flour. The physical properties of moringa-corn bread are presented in Table 3 below.

The results of analysis of variance showed that the addition of moringa leaves flour had a very significant effect on the volume of bread and the specific volume and elasticity of moringa-corn bread. Table 3 shows that the volume of bread and the specific volume of bread and also the elasticity of bread decreases with increasing concentration of moringa flour. These physical properties are closely related to the use of flour raw materials, both wheat flour and composite flour related to gluten protein. Różyło *et al*. (2015) explained that the level of dough development, the specific volume of bread and the elasticity of the dough were strongly influenced by the added raw materials. Research by Trisnawati & Nisa (2014) shows that the more protein concentrate of moringa leaves is added, the proportion of gluten derived from wheat flour contained in the dough will decrease, thereby reducing its elasticity value. Likewise, Husna (2017) states that the more non-starch components (fiber) in moringa leaves extract causes the elastic properties of the noodles to decrease so that they will break easily if there is pressure in the form of a pull or strain.

Table 3. The effect of the addition of moringa leaves flour on changes in the physical properties of moringa-corn bread

Moringa leaves flour addition	Changes on physical properties of moringa-corn bread		
	Bread volume (cm^3)	Specific volume (cm^3/g)	Elastisity (%)
TK1	163.54 a	4.39 a	81.85 a
TK2	119.84 b	3.29 b	73.63 b
TK3	129.90 b	3.71 b	75.14 ab
TK4	98.33 c	2.73 c	60.82 c

Note: Average values followed by with different lowercases mean significantly different at DMRT 5%.
TK1 = Moringa leaves flour consentration 1%
TK2 = Moringa leaves flour consentration 3%
TK3 = Moringa leaves flour consentration 5%
TK4 = Moringa leaves flour consentration 7%

In Table 1 it can be seen that the higher the content of moringa leaves flour added, the higher the protein content. This increase in protein content is inversely proportional to the volume of developer where the higher the content of moringa leaves flour, the lower the volume of development, because moringa leaves flour does not contain gluten protein. The more moringa leaves flour is added, the gluten content in the cornbread dough becomes less and less available, thereby reducing the swellability of the resulting bread. Gluten will determine the results of the product because gluten will affect the tissue or framework that will affect whether the product is good or not. This shows that the role of gluten is disappearing because it is added that gluten-free moringa leaves flour is added so that with the addition of moringa leaves flour, the resulting swelling power decreases. This is in accordance with the research of Aryani *et al*. (2019) which states that the higher the content of moringa leaves leaf flour, the lower the volume of development. According to Dhaka & Khatkar (2015), the main components forming gluten polymers are gliadin and glutenin which produce elasticity properties. Gluten is needed to hold the gas from yeast fermentation in bread making

so that the bread can expand. Gliadin will cause gluten to be elastic while glutenin causes dough to be strong to hold gas and determine the structure of the product to be baked.

The volume of bread and the specific volume and elasticity of bread were highest with the addition of 1% moringa leaf flour with a bread volume of 163 cm^3, the specific volume of bread 4.39 cm^3/g and the elasticity of bread was 81.85%, and it decreased and was significantly different from the addition of 3% moringa flour. and 5%. Bread volume and specific volume as well as bread elasticity were lowest at the addition of 7% moringa leaves flour with bread volume 98.33 cm^3, bread specific volume 2.73 cm^3/g and bread elasticity 60.82%. When associated with gluten content, moringa leaves flour does not contain gluten. Borla et al. (2004) also reported that the addition of gluten to wheat flour can increase the development of white bread. The greater the ratio of moringa leaves flour added, the lower the swelling ability of moringa-corn bread, thereby reducing the volume and elasticity of moringa-corn bread. As a comparison is the research of Rauf & Andini (2019), that the greater the ratio of cassava flour, the smaller the dough development and the lower the level of development of white bread.

From all these physical properties, it can be seen that the more addition of moringa leaves flour (up to 7%) fortified on corn bread causes a decrease in the specific volume and elasticity of the bread and also a decreased of sensory value. The work of Medho & Muhamad (2020) showed that the lowest hedonic value was given to the addition of 7%. This means that the panelists do not like the bread with dark green color, the texture is a bit hard, rough, inelastic, bitter taste and dry, wrinkled impression in the mouth, and unpleasant smell. While the best sensory value is given to the addition of 5% moringa leaves flour fortified on corn bread. Meanwhile, research by Augustyn *et al*. (2017) with the addition of 3% moringa leaves flour produced biscuits with good organoleptic and chemical characteristics.

4. CONCLUSION

The highest macro and micro nutritional values in the addition of 7% moringa leaves flour and inversely proportional to the physical properties of the bread, namely a decrease in the specific volume and elasticity of moringa-corn bread which resulted in a decrease in panelists' acceptance of moringa-corn bread products. The addition of moringa leaves flour with a concentration of 5% was the best with a protein value of 7.27 mg/100g, vitamin C 60.0 mg/100g, β-Carotene 13,909.99 mg/100g), specific volume of bread 3.71 cm^3/g and bread elasticity 75.14% as well as sensory acceptance supreme moringa-corn bread.

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