

Characteristics of Modified Timor White Corn Flour and its Cookies Enriched with Moringa Leaves

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Article History:

Received : 01 December 2023

Revised : 29 December 2023

Accepted : 05 February 2024

Keywords:

Composite flour,
Fortification,
Pasting characteristics,
Organoleptic test,
Preferences.

ABSTRACT

Composite flour consisted of local Timor white corn and moringa leaf flours are rich in protein, crude fiber and dietary fiber but are relatively limited in use as ingredients for making cookies. This study aims to determine the characteristics of modified local Timor white corn flour and moringa leaves and their composite flour on the physico-chemical characteristics and sensory acceptance of corn cookies fortified with moringa. The research was conducted experimentally with 5 treatments on the proportion of corn flour to moringa flour, including F0 (100: 0), F1 (99:1), F3 (97:3), F5 (95:5), F7 (93:7). The results showed that the proportion of F7 composite flour have start time gelatinization 8.53 minute faster than the other formulation, and not significantly different from F3 and F5 but significantly different from F1 and F0. There was a significant decrease in the peak, final, hot paste, breakdown, and setback viscosity values, due to the fortification of moringa leaf flour. The difference in the proportion of corn and moringa leaf composite flour had no significant effect on sensory values texture, taste and smell but had a very significant effect on cookies color. The flour formulations F3, F5, and F7 produced cookies with higher protein, crude fiber and other dietary fiber values and had fulfilled the cookies requirements according to SNI 2973:2011.

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1. INTRODUCTION

Local white corn from Timor is one of the varieties cultivated in several regions of Timor Island in East Nusa Tenggara Province (NTT) and is considered indigenous. There are two types of this corn variety with local names: white corn “kapur” (chalk) and “batu” (stone). The physical characteristics of chalk corn grains include a bone-white color and a chalky white endosperm, making them light and not too hard in texture. When milled, they crumble easily, so the Timorese people prefer to use them to make a traditional Timorese food product locally called “jagung ketemak” (corn boiled without milling). Stone corn, on the other hand, has a harder texture and, when milled, does not crumble easily, with the bran separating effectively, making it suitable for another traditional Timorese food product called “jagung bose”. The potential of this white corn can be further developed into other processed food products, such as cookies that add value and can be consumed by various groups. The main ingredient for making cookies is flour, so this corn needs to be processed into flour first.

Corn flour processed traditionally by the local community has several limitations, including relatively low protein content, less appealing physical properties, especially in terms of color and aroma, and relatively short shelf life. Therefore, it is necessary to modify corn flour both enzymatically and through fermentation. This modification is expected to bring changes in the physicochemical and functional properties of the corn flour. Research by Aini *et al.*

(2016) on corn fermentation using yeast found from the market, *Lactobacillus bulgaricus* and *Lactobacillus casei* affects the properties of corn flour in term of physicochemical and functional. The study by Medho *et al.* (2018) showed that chemically, local white corn flour from Timor fermented with 2% concentration of *Lactobacillus casei* for 36 h could increase protein content to 8.7–10%. Despite the increase in protein value, the use of corn flour as an effort to diversify processed food products needs to consider other nutritional values, especially micronutrients. The problem with corn flour is the deficiency of several micronutrients including minerals as well as vitamins A, B, and C.

This micronutrient deficiency in corn flour can be addressed by fortification or supplementation with other local ingredients such as “kelor” leaves (*Moringa oleifera*). The nutritional content of dried moringa leaves includes 26.02% protein, 9.57% moisture, 1.92% vitamin C, 7.85% ash, 51.91% carbohydrates, 2.52% fat, and 4.03% fiber (Augustyn *et al.*, 2017). Moringa leaves also contain micro-nutrients such as beta carotene, vitamin C, thiamin (B1), riboflavin (B2), and niacin (B3), as well as calcium (Ca), iron (Fe), phosphorus (P), magnesium (Mg), and zinc (Zn). Research by Verem *et al.* (2021) showed an increase in the content of minerals Zn, Fe, Ca, P, and vitamins C, A, B1, B2, and B3 with the increase of moringa leaf flour in the composite flour of wheat and soybean enriched with moringa leaves. Moringa leaves also contain higher antioxidant flavonoids compared to moringa stems and have the ability to neutralize free radicals and inhibit lipid peroxidation (Fitri *et al.*, 2015).

As a fortification ingredient, moringa leaves have a distinct taste due to their tannin content and raw aroma. Tannins can cause astringency and bitterness because they form cross-links with proteins or glycoproteins in the mouth, leading to a dry and puckered sensation. Research by Medho & Endeyani (2019) found that the unpleasant smell (“langu”) and bitter taste of moringa leaf flour can be reduced by blanching of fresh moringa leaves at 80 °C for 3 min, with a smaller reduction in micronutrient values compared to blanching for 5 and 7 min.

The utilization of modified corn flour fortified with moringa leaf flour has been conducted to make bread (Medho & Endeyani, 2021). The results showed that bread using 40% corn flour substitution and enrichment of 5% moringa leaf flour revealed the most sensory approval by panelists. The bread contain protein of 7.27 mg/100g, beta carotene of 13,909.99 µg, vitamin C of 60.0 mg/100g, bread elasticity of 75.14%, and specific bread volume of 3.71 cm³/g. Research by Cengceng *et al.* (2020) indicated an increase in Fe mineral content (reaching 4.19%) and the increase of antioxidant activity up to 35,006 µg/mL (highly strong) in plain bread enriched with 12% moringa leaf flour. Based on organoleptic scores in all attributes, however, the addition of 4% moringa leaf flour was more accepted. Research has also been developed for other products, such as cookies. The addition of moringa during processing cookies and other foods can increase the macro and micronutrient values. However, organoleptic values also need to be considered. Dewi (2018) showed that the fortification of 40% moringa leaf flour resulted the highest panelist acceptance (texture, taste and color) compared to that of 60% moringa leaf flour addition, although panelists strongly dislike the aroma of cookies with high amount of moringa flour. Based on the development of modified corn flour utilization with moringa leaf flour fortification, research on the utilization of composite flour from local white corn from Timor with moringa leaf flour in the making of moringa corn cookies is required. This research aims to determine the characteristics of composite flour from modified local white corn from Timor with moringa leaves, as well as the effect of adding moringa leaf flour on the physicochemical characteristics and sensory acceptance of moringa corn cookies. The benefits of this research include the development of studies on moringa flour, corn flour, and the final product of moringa corn cookies, which will be utilized in the food industry.

2. MATERIALS AND METHODS

2.1. Materials

The primary materials in flour production included local Timor white corn (milled, stone type), fresh moringa leaves, and yeast (*Saccharomyces cerevisiae*). For cookie production, the ingredients were composite flour made from modified local white corn and moringa leaves, butter, salt, and sugar. The main equipment for making flour included a grinder and sieve (80 mesh). The equipment to make cookies included scales, a baking oven, a hand mixer, baking trays, cookie molds, plastic wrap, and other cooking utensils. The main tools used for analysis were a Minolta CR 300 chromameter, Soxhlet flask, Kjeldahl flask, fat flask, furnace, distillation apparatus, drying ovens, desiccators, aluminum cups, porcelain cups, aluminum foil, baking trays, filter paper, and glassware.

2.2. Methods

The study was carried out in two stages. The first stage involved the production of modified corn flour (using yeast *Saccharomyces cerevisiae*) and moringa leaf flour, as well as the characterization of the gelatinization profile of the composite flour made of corn and moringa leaves flours. The production of moringa flour follows the steps in the research by [Medho & Endeyani \(2019\)](#). The samples are taken based on their position on a single branch of the moringa tree, specifically from the middle part of the branch. The sorted moringa leaves are then blanched at 80 °C for 3 min. The next step involves drying the leaves under full sunlight for 3 h until they can be easily broken or fully dried. Once dried, the moringa leaves were then milled using a stainless steel grinder and screened using 80 mesh sieve, and weighed to calculate the yield of moringa flour.

The production of modified flour of local white corn through fermentation followed the steps in [Aini et al. \(2016\)](#). This involved fermentation of hulled white corn using yeast *Saccharomyces cerevisiae* for 24 h. After that, the corn was drained and dried under sun light until completely dry for 8 h, to achieve moisture content below 14%. The next step was grinding the corn and sieving it using an 80 mesh sieve. The amount of corn was 13 kg (13,000 g). The corn was ground twice and sieved to obtain flour with a size of 80 mesh. The flour yield was calculated based on:

$$\text{Flour yield (\%)} = \frac{\text{final weight}}{\text{initial weight}} \times 100\% \quad (1)$$

Characterization was conducted on the corn flour, moringa flour, and the mixture of them. The composite flour of modified local white corn and moringa leaves flours was formulated with ratio of corn flour to moringa leaf flour as follows: F0 (100:0), F1 (99:1), F3 (97:3), F5 (95:5), and F7 (93:7). The study used a Completely Randomized Design (CRD) with 4 replications.

The second stage involved formulation and production of cookies based on modified corn flour enriched with moringa leaf flour as well as characterization of the cookies. The step for making cookies referred to [Harmayani et al. \(2011\)](#), with modifications to the basic formulation, consisting of three stages: mixing, molding, and baking. The dough preparation begun by creaming margarine and powdered sugar for approximately 3 min. Then, eggs and salt were supplemented and thoroughly mixed for another 2 min. Other ingredients, such as composite flour from corn and moringa leaves, are added and mixed until a dough was formed. The next stage, molding, was done using a mold with a diameter of 3.5 cm and a thickness of 0.5 cm. The molded dough is baked in an oven at approximately 170 °C for 15 min. The modification and formulation of the basic cookie recipe based on the proportion of modified corn flour and moringa leaf flour were presented in Table 1.

Table 1. Basic cookie formulation design based on the proportion of composite corn flour and moringa leaf flour

Ingredients	Ingredient formula (%)				
	F0	F1	F3	F5	F7
Flour (100%)					
Modified corn flour	100	99	97	95	93
Moringa leaf flour	0	1	3	5	7
Other ingredients (100%)					
Margarine	75	75	75	75	75
Powdered sugar	25	25	25	25	25
Salt	0.1	0.1	0.1	0.1	0.1

2.3. Chemical Analysis

The analysis included proximate based on SNI 01-2891 (BSN 1992), crude fiber, and dietary fiber ([AOAC 2005](#)).

2.3.1. Pasting Characteristics ([Faridah et al., 2014](#))

The gelatinization profiles of modified local white corn flour, moringa leaf flour, and composite flour were examined using a Rapid Visco Analyser (RVA). For each analysis, 3 grams of the dry sample were placed in the RVA container, followed by the addition of 25 grams of distilled water. The RVA process included heating and cooling phases with

continuous stirring at 160 rpm. During the heating phase, the starch mixture was heated from 50 °C to 95 °C at a rate of 6 °C per minute, then maintained at 95 °C for 5 minutes. Subsequently, the cooling phase lowered the temperature from 95 °C to 50 °C at the same rate over 2 minutes. The RVA instrument recorded the gelatinization profile, plotting viscosity (cP) against temperature changes (°C) during both the heating and cooling phases. Pasting characteristic data included initial pasting temperature (PT), peak viscosity (PV), breakdown viscosity (BDV), setback viscosity (SV), and final viscosity (FV).

2.3.2. Color Analysis (Yuniarsih *et al.*, 2018)

Color measurements were performed using a Minolta CR 300 chromameter. The chromameter was first calibrated using a calibration plate. The measurements were repeated three times for each sample to get the average values. The chromameter measurements included Hunter values of L^* , a^* , and b^* . The L^* values vary from 0 (zero) for black to 100 for white. Positive a^* values indicated red-purple hue, while negative a^* values indicated blue-green hue. Positive b^* values indicated yellow hue, while negative b^* values indicated blue hue.

2.3.3. Total Dietary Fiber Analysis

Total dietary fiber analysis referred to Rismaya *et al.* (2018) using 1 g of sample (W). The total fiber content was calculated according to Equation (2):

$$\text{Total fiber content (\%wet basis)} = \frac{W_{res} - W_{pro} - W_{abu} - W_b}{W} \times 100 \quad (2)$$

where W_{res} is the weight of residue, W_{abu} is the weight of ash after burning with furnace at 525°C for 5 h, W_{pro} is the weight of protein content using the Kjeldahl method, and W_b is the weight of contaminants from reagents and enzymes in the blank sample.

2.3.4. Hedonic Rating Test (Breshears & Crowe, 2013)

A sensory test of cookies using the hedonic rating method was conducted to determine the most acceptable one for consumers. The sensory test conducted was a hedonic test to evaluate the level of preferences about color, texture, taste, and overall impression. The scoring used in the assessment ranged from 1 to 7, where 7 = very like, 6 = like, 5 = slightly like, 4 = neutral, 3 = slightly dislike, 2 = dislike, and 1 = very dislike. Organoleptic assessments were conducted by 25 untrained panelists, consisting of faculty members and students aged 18-45 years. Subsequently, an analysis of variance was performed on the sensory test data.

2.4. Statistical Analysis

Statistical analysis was carried out under completely randomized design (CRD), except for the acceptance test which used randomized block design (RBD). The observed data were analyzed using analysis of variance (ANOVA) with a confidence interval of 95% using the SPSS 15.0 program. If significant differences were found, post-hoc tests were conducted using the Duncan Multiple Range Test (DMRT) for all parameters at the same significance level.

3. RESULTS AND DISCUSSION

3.1. Yield of Corn Flour and Moringa Flour

The amount of corn after milling was 13 kg (13,000 g), and the amount of flour with a size of 80 mesh was 4.45 kg (4,450 g). The flour yield was calculated based on Equation (1) and resulted a yield value of 34.23%. This value is lower as compared to that of obtained by Aini *et al.* (2016) using yeast *Lactobacillus casei* where corn flour yield of 47.1% and 49.5% was reported for fermentation duration of 40 h and 60 h, respectively. Different fermentation media and fermentation duration result in different yields. Fermentation causes corn kernels to swell, making them softer. Soaking corn grains in the fermentation process changes the hard part of the endosperm (horny endosperm) into a soft part (floury endosperm) which is easier to grind. Additionally, these microorganisms are able to degrade corn cell walls, allowing starch granules to emerge from the cells, facilitating the milling process.

Meanwhile, the moringa leaf flour yield with a particle size of 80 mesh is 15.2%. This low yield is due to the use of fresh moringa leaves with high water content, resulting in significant water evaporation during drying, thus obtaining a moisture content of moringa flour of 7.43%.

3.2. Characteristic of Flours

Gelatinization properties indicate the functional properties of corn flour, moringa leaf flour, and composite flour produced. The parameters observed are initial gelatinization temperature, maximum viscosity, peak gelatinization temperature, viscosity breakdown, and setback viscosity. Gelatinization properties of corn flour and composite flour are presented in Table 2.

Table 2. Influence of proportion of composite corn and moringa leaf flour on gelatinization properties

Flour Composite	Gelatinization Properties								
	PV(Cp)	HPV (Cp)	BDV (Cp)	BDV/PV	SV(cp)	FV (Cp)	SV/FV	Pt (min)	PT (°C)
F0	2590±1.00 ^c	1999±0.58 ^c	591±0.50 ^c	0.23	3171±0.50 ^c	5170±0.96 ^c	0.61	8.73±0.00 ^d	76.45±0.02 ^a
F1	2226±0.58 ^d	1643±0.96 ^d	583±0.96 ^d	0.26	3056±0.50 ^d	4699±0.58 ^d	0.65	8.67±0.01 ^c	76.80±0.00 ^b
F3	1987±0.58 ^c	1516±0.96 ^c	471±0.50 ^c	0.24	2611±0.58 ^c	4127±0.06 ^c	0.63	8.54±0.00 ^{ab}	78.15±0.00 ^d
F5	1940±0.50 ^b	1470±0.58 ^b	470±0.50 ^b	0.24	2581±0.50 ^b	4051b±0.50	0.64	8.53±0.00 ^a	78.05±0.01 ^c
F7	1859±0.96 ^a	1431±0.50 ^a	428±0.58 ^a	0.23	2339±0.58 ^a	3770±0.50a	0.62	8.53±0.00 ^a	78.90±0.01 ^c
Moringa	43±0.50	37±0.50	6±0.00	0.14	20±0.50	570.±0.50		12.47±0.00	

Note: The same letters followed numbers in the same column indicate no significant difference according to DMRT at 95% confidence level. (PV = Peak viscosity; HPV = Hot paste viscosity; BDV = Breakdown viscosity; SV = Setback viscosity; FV = Final viscosity; Pt = Time to reach peak viscosity; PT = Pasting temperature or gelatinization temperature).

3.2.1. Initial gelatinization temperature and time

The measurement results of the gelatinization paste profile in Table 2 indicate that the proportion of composite corn flour and moringa leaf powder significantly affects the initial gelatinization temperature and time, showing a very significant difference between treatments. The gelatinization temperature of corn flour (F0) is lower, at 76.45 °C, compared to the gelatinization temperature of thread taro flour in the study by [Yuniarsi *et al.* \(2019\)](#), which is 79.7 °C. This discrepancy is attributed to the different starch sources with varying molecular weights. According to [Imanningsih \(2012\)](#), corn starch, categorized as cereal starch, has a lower molecular weight compared to thread taro starch, which is classified as tuber starch, resulting in a lower gelatinization temperature for corn flour compared to thread taro flour. The gelatinization temperature increases with each addition of moringa leaf powder, with the highest gelatinization temperature observed in the F7 composite flour (93:7) at 78.9 °C. This is inversely related to the initial gelatinization time, where a higher proportion of moringa leaf powder results in a faster initial gelatinization time. The F7 composite flour proportion shows a quicker initial gelatinization time of 8.53 min, which is not significantly different from the F3 and F5 composite flour proportions but is significantly different from the F1 and F0 composite flour proportions. This is influenced by the fact that the more moringa leaf powder added, the higher the initial gelatinization temperature, and the faster the initial gelatinization time. Another factor is the high gelatinization temperature caused by a high level of crystallinity and relatively small granule size. For comparison, the initial gelatinization temperature of corn flour fermented with tape yeast for 24 h is 76.45 °C. This value is lower compared to the study by [Aini *et al.* \(2016\)](#), which is 78.7 °C. Compared to the study by [Medho *et al.* \(2018\)](#), the initial gelatinization temperature of corn flour fermented with *L. casei* bacteria is lower at 74.9 °C. This difference is due to the different types of yeast used and the different corn varieties, even though both studies used white corn.

3.2.2. Peak Viscosity, Hot Paste Viscosity, Final Viscosity, Breakdown, and Setback Viscosity

The peak viscosity of the composite corn and moringa leaf flour ranges from 1859 to 2590 Cp, with the lowest peak viscosity (1859 Cp) at the 93:7 corn flour to moringa leaf powder ratio (F7) and the highest (2590 Cp) in pure corn flour without moringa leaf addition (100:0, F0). Table 2 shows that the peak viscosity decreases with the increasing addition of moringa leaf powder. Similarly, the hot paste viscosity decreases with the increasing addition of moringa leaf powder due to the increased protein content in moringa leaves. This trend is consistent with the study by [Yuniarsi](#)

et al. (2019), where the peak viscosity decreased with the increasing addition of moringa leaf powder to composite taro and moringa leaf flour.

The breakdown viscosity of corn flour is higher in the F0 treatment (corn flour without moringa leaf powder) at 591 Cp and decreases with each addition of moringa leaf powder, reaching its lowest in the F7 treatment at 428 Cp. Table 2 also shows that the breakdown viscosity values differ significantly across all composite flour formulations. The stability of the paste against heat can be compared by analyzing the breakdown viscosity relative to the peak viscosity, where a smaller ratio indicates a more stable paste. Based on this comparison (Table 2), the addition of moringa leaf powder reduces the thermal stability of corn flour paste.

Setback viscosity, as seen in Table 2, shows a very significant difference. All composite flour formulations exhibit very significant differences in viscosity values, and the setback viscosity decreases as more moringa leaf powder is added. The higher the setback viscosity value, the greater the tendency for retrogradation. The final viscosity in Table 2 also shows a very significant difference across all composite flour formulations. The final viscosity values differ significantly in all composite flour formulations and decrease with the addition of 7% moringa leaf powder. The comparison of setback viscosity to final viscosity better illustrates the tendency for retrogradation. The addition of moringa leaf powder up to 7% in corn flour does not affect the tendency for retrogradation because the paste profile remains the same, with the ratio of setback viscosity to final viscosity being the same. The tendency for starch retrogradation is related to the amylose content. Retrogradation occurs faster in the linear structure of amylose with the formation of hydrogen cross-link bonds. Retrogradation in amylopectin occurs after several days. The rate and extent of starch retrogradation after gelatinization depend heavily on the amount of amylose (Millati & Nurhayati, 2020). According to Yuniarsi *et al.* (2019), a low setback viscosity is important for frozen or cold food products. Moringa leaf powder has low viscosity and no initial pasting temperature. This is because moringa leaf powder contains little starch, while its protein and dietary fiber content is high. Moringa leaf powder is very heat-stable, with a lower ratio of breakdown viscosity to peak viscosity at 0.14 (Table 2). The structure of starch (amylose and amylopectin molecules) is a major factor influencing the properties of starch paste.

3.3. Physical and Chemical Properties of Cookies

3.3.1. Cookie Color

The color analysis of the cookies was conducted using a chromameter. This test was performed on 5 treatments with 4 repetitions for each treatment. The results are expressed as L^* , a^* , and b^* values. The L^* value indicates the brightness level of the cookies (0 = black, while 100 = white). The a^* and b^* values show the color tendencies of the cookies. The average color values of the cookies are presented in Table 3. It can be seen that the color produced by cookies with varying proportions of composite corn and moringa leaf flour has significant differences. Cookies made with corn flour without the addition of moringa leaf flour have a bright yellow color with a slight brown tint. As the proportion of moringa leaf flour increases, the cookies' color becomes progressively greener with a slight brown tint.

The highest average L^* value is found in F0 cookies, at 40.26, and the lowest is in F3 cookies, at 25.89. The L^* value indicates the lightness and darkness of the cookies' color. Cookies made from corn flour without the addition of moringa leaf flour tend to have a bright yellow color, whereas cookies made from a composite of corn flour and moringa leaf flour tend to be darker. The higher the moringa flour content in the cookies, the lower the L^* value. This is because moringa flour, which has a dark green color, is used as a base ingredient. The cookies tend to be darker green due to the chlorophyll pigment, but they appear slightly brownish-green. This occurs due to the Maillard reaction during baking, producing melanoidin compounds responsible for the brown color. This reaction happens due

Table 3. Effect of composite corn and moringa leaf flour proportions on cookie color

Flour Composite	The average color values of corn and moringa leaf cookies		
	L^*	a^*	b^*
F0	40.26±0.73 ^c	16.20±0.34 ^e	18.30±0.39 ^e
F1	37.81±1.07 ^d	12.92±0.52 ^b	17.08 ±0.40 ^d
F5	28.02±0.78	12.95±0.30 ^{bc}	10.72±0.79 ^{bc}
F7	29.22±0.53 ^c	13.75±0.62 ^{cd}	10.10±0.62 ^b

Note: The same letters followed numbers in the same column indicate no significant difference according to DMRT at 95% confidence level.

to the interaction between amino groups from proteins and reducing sugars at high temperatures. The color difference in cookies can also be attributed to variations in the color of the flour used, uneven heat distribution, and the Maillard reaction during baking.

The a^* value in cookies with composite corn and moringa leaf flour shows a significant difference. As more moringa flour is added, the a^* value decreases, but remains positive across all formulas. Similarly, the b^* value is positive in all formulations, indicating a tendency toward yellow rather than blue.

3.3.2. Chemical Properties of Cookies

The chemical properties of cookies are related to the protein content, crude fiber, dietary fiber, moisture content, and ash content that meet the requirements of cookies according to SNI 2973:2011 (BSN 2011). The chemical properties of cookies made from composite corn and moringa leaf flour are presented in Table 4. It shows that the proportion of composite flour from local white corn from Timor and moringa leaf in cookie making significantly influences (shows significant differences) some chemical properties of the resulting cookies. The proportion of corn flour and moringa leaf flour significantly influences the content of water, protein, ash, crude fiber, and dietary fiber in the cookies, but does not significantly differ in fat content.

Table 4. Chemical composition of cookies made from composite corn and moringa leaf flour

Chemical Composition	Composite Corn and Moringa Leaf Flour					SNI 2973-2011
	F0	F1	F3	F5	F7	
Moisture content (db)	4.37±0.22 ^b	3.62±0.62 ^{ab}	2.86±0.43 ^a	3.97±0.54 ^{ab}	4.61± ^b	Max 5
Protein content (db)	3.69±0.11 ^a	4.06±0.27 ^{ab}	4.98±0.41 ^c	5.07±0.35 ^c	5.40± ^c	Min 9
Fat content (db)	29.4±0.76 ^a	29.19±0.65 ^a	29.67±0.19 ^a	30.11±0.46 ^a	29.43± ^a	Min 9.5
Ash content (db)	1.25±0.21 ^{ab}	1.09±0.04 ^a	1.28±0.10 ^{abc}	1.46±0.15 ^{bcd}	1.54± ^d	Max 1.5
Carbohydrate content (db)	57.33±1.02 ^c	56.15±2.17 ^c	56.47±0.73 ^c	52.72±0.40 ^{ab}	52.48±0.58 ^a	Min 70
Energy (kcal/100g)	501.1±3.24 ^{bcd}	497.7±1.28 ^{ab}	507.1±0.57 ^d	498.7±7.53 ^{abc}	491. ±4.47 ^a	Min 400
Crude fiber (%)	4.13±0.39 ^a	4.75±0.58 ^{ab}	5.89±0.50 ^c	6.44±0.93 ^c	6.55±0.37 ^c	Max 0.5
Dietary fiber (%)	7.03±0.29 ^a	9.00±0.64 ^b	9.24±0.65 ^b	9.50±0.30 ^b	9.59±0.51 ^b	Min 6

Note: The same letters followed numbers in the same row indicate no significant difference according to DMRT at 95% confidence level

Moisture Content

Based on the observations, it can be seen that the proportion of composite flour from local white corn and moringa leaf significantly influences (shows significant differences) the moisture content of cookies. The moisture content of corn cookies without the addition of moringa leaf flour (F0) is 4.37% higher and not significantly different from F7, which is 4.61%, but significantly different from F3. The moisture content of cookies in the F3 formulation does not significantly differ from the moisture content of cookies made from composite corn and moringa leaf flour in the F1 and F5 formulations. This means that moringa leaf also has a strong influence on the moisture content which increase along with the higher proportion of moringa leaf flour in the formulation. This is due to the high moisture content of moringa flour, which is 7.43%, and the moisture content of corn flour, which is 8.67%. However, the average moisture content of these composite flour cookies is very low and meets the requirement for cookie moisture content, which is a maximum of 5% (Cookie quality requirements according to SNI 2973-2011).

The decrease in cookie moisture content is due to one of the processes in this study, namely baking. There are several important occurrences that happen during baking, including dough expansion, protein coagulation, starch gelatinization, and water evaporation. Heating will cause starch gelatinization, where starch granules will swell due to water absorption. The swelling of starch granules is limited to about 30% of the flour weight. When the swelling of starch granules reaches the limit, the granules will rupture, resulting in water evaporation.

Protein

It is evident from Table 4 that the protein content of cookies made from composite flour increases with the addition of moringa leaf flour, although the protein content in these cookies is still lower than the minimum requirement stipulated in (BSN 2011), which is 9%. Several reasons account for the low protein content in cookies made from

composite corn and moringa leaf flour. Firstly, the baking temperature plays a significant role. As a comparison, the initial protein content of corn flour fermented with tape yeast for 20 hours was reported to be 7.6% (db) (Aini *et al.*, 2016). In this study, the protein content of corn cookies without the addition of moringa leaf flour in the F0 treatment decreased to 3.69% due to the baking process. The initial protein content of moringa leaf flour was also relatively high in studies by Erniyanti *et al.* (2019) (28.99%) and Augustyn *et al.* (2017) (26.02%). However, there was a decrease in protein content in the production of moringa biscuits, with a value of 10.12%, due to denaturation during baking. This occurs because during the baking process, proteins undergo denaturation as they cannot withstand the heat. According to Yusuf (2018), protein will be denatured from its native state when the protein solution is heated above its critical temperature. The mechanism of temperature-induced protein denaturation is quite complex and leads to the destabilization of non-covalent interactions within the protein. Another reason is that (2) eggs are not added in the production of cookies made from composite corn and moringa leaf flour, and (3) the amount of moringa leaf flour added is minimal.

Ash Content

Ash content is a mixture of inorganic components or minerals found in processed food ingredients. Based on Table 4, it can be seen that the proportion of composite flour from local white corn from Timor and moringa leaf significantly influences (shows very significant differences) the ash content of cookies. The lowest ash content of cookies is 1.09% with the addition of 1% moringa leaf flour, and it is not significantly different from the ash content of cookies without moringa leaf flour, which is 1.25%. With each increase in moringa leaf flour, the ash content of cookies significantly increases, as evidenced by the ash content of cookies with 7% moringa leaf flour being 1.54%.

The average ash content of cookies made from composite corn and moringa leaf flour meets the requirement for cookie ash content, which is a maximum of 1.5 (Cookie quality requirements according to SNI 2973-2011). If the amount of moringa leaf is increased, the resulting ash content will be higher. Therefore, the limit for adding moringa leaf flour in composite flour formulations is 5%.

Crude Fiber Content

Table 4 indicates that the proportion of composite flour from local white corn from Timor and moringa leaf significantly influences (shows very significant differences) the crude fiber content of cookies. The lowest crude fiber content of cookies is 4.13% without the addition of moringa leaf flour (F0), and it is not significantly different from the crude fiber content of cookies with 1% moringa leaf flour, which is 4.75%. With each increase in moringa leaf flour, the crude fiber content of cookies significantly increases, as evidenced by the crude fiber content of cookies with 7% moringa leaf flour being 6.55%.

According to SNI 01-2973-1992 regarding the quality requirements for cookies, the maximum crude fiber content of cookies is 0.5% (db). Thus, the crude fiber content of the cookies from this study does not meet the characteristics or quality requirements of cookies. However, this research with the proportion of composite flour from local white corn and moringa leaf flour shows that the higher the moringa leaf flour content, the higher the crude fiber. Research by Verem *et al.* (2021) suggests that the proportion of composite flour from wheat, lentils, and moringa leaves shows higher crude fiber content with higher concentrations of moringa leaves and lower amounts of wheat flour, with a crude fiber content of 3% at a proportion of wheat flour: lentils: moringa leaves (60:20:20). Foods with relatively high crude fiber content usually have low calories, low sugar, and low-fat content, which can help reduce obesity and heart disease. In short, foods with relatively high crude fiber content are also reported to prevent diverticulosis due to reduced pressure on the walls of the digestive tract, resulting in improved food transit time.

Dietary Fiber Content

Dietary fiber is the plant food residue that is resistant to hydrolysis by human digestive enzymes. Crude fiber, on the other hand, is the plant food residue that remains after being chemically digested harshly. Dietary fiber is a non-starch polysaccharide found in all plant foods. Dietary fiber provides beneficial physiological effects such as acting as a laxative, lowering blood cholesterol, and reducing blood glucose levels. Food is considered a source of dietary fiber if the dietary fiber content is not less than 3 g/100 g of food, and it is considered high in fiber if the dietary fiber content is not less than 6 g/100 g (BPOM, 2016).

The results of measuring the dietary fiber content (Table 4) show that the proportion of composite flour from corn and moringa leaves (F7: 93:7) increases the crude fiber and dietary fiber content of cookies, with the dietary fiber content of cookies being 9.59%. The more moringa leaf flour in the formulation, the higher the dietary fiber content of the cookies. According to the BNJ further test, cookies with the formulation of corn flour without the addition of moringa leaf flour (F0: 100:0) showed a significant difference from the formulation of composite flour from corn and moringa leaves (F1: 99:1). Meanwhile, formulation F1 did not significantly differ from formulations F3, F5, and F7. The lowest dietary fiber content was in the cookies without the addition of moringa leaf flour, with a dietary fiber value of 7.03%, and the highest was in F7 with a dietary fiber value of 9.59%. On average, the resulting cookies are classified as high-fiber foods because they meet the minimum dietary fiber requirement of 6%. The increase in the dietary fiber content of corn-moringa cookies due to the addition of moringa leaf flour is related to the high fiber content of moringa leaf flour. This is consistent with the study by [Rismaya et al. \(2018\)](#), which found that the increase in dietary fiber content in muffins due to the addition of pumpkin flour is related to the high fiber content of pumpkin flour. The study by [Wulandari et al. \(2016\)](#) also showed that the crude fiber content of cookies with jackfruit flour substitution increased with the addition of jackfruit flour, and at a concentration of 50%, a crude fiber content of 2.50% was obtained, but the crude fiber value of jackfruit flour-substituted cookies was lower than that of corn-moringa cookies.

3.4. Sensory Acceptance of Corn Cookies

The sensory characteristics of cookies made from corn and moringa composite flour observed include color, aroma, taste, and texture. The color, taste, and aroma of the cookies are highly dependent on the ingredients used, namely corn and moringa composite flour. The resulting cookie color is green, with a sweet taste and no bitterness, and a distinctive aroma of moringa leaves and corn. The results of the sensory acceptance analysis of the composite flour cookies are presented in Table 5. The addition of moringa leaf flour in the proportion of composite corn and moringa leaf flour does not significantly influence the hedonic value for all attributes: color, texture, taste, and aroma in corn moringa cookies. However, the higher the concentration of moringa leaf flour in all formulations, the product's color becomes slightly greener with a hint of brown. This is because moringa flour is green, resulting in corn moringa cookies having a green color. The dark green color comes from the β -carotene and chlorophyll pigments in the moringa leaves. The more moringa leaf flour added, the darker the green color of the corn moringa cookies. However, the panelists' acceptance of the color did not significantly differ in all formulations, including the formulation without the addition of moringa leaf flour (corn flour cookies) with a slightly brownish yellow color. Similarly, the texture of the cookies, referring to crispiness and softness, is not significantly affected by the addition of moringa leaf flour, even in large quantities, because moringa has very low fat content. The crispy texture of corn moringa cookies is due to the addition of butter in equal amounts, which is 75%. As a comparison, the substitution variations of mocaf flour and kepok banana flour did not significantly affect the panelists' preference level for the texture of cookies with mocaf flour and kepok banana flour substitution. The texture of cookies is influenced by the presence of fat and amylose content. The presence of fat in cookies breaks down their structure and then coats the starch and gluten, resulting in crispy cookies ([Oktaviana et al., 2017](#)). According to [Winarno \(2008\)](#), the addition of margarine in making cookies provides plasticity essential for making crispy cookies. Margarine is elastic, making the dough easy to shape, resulting in crispy products. Fat is not dissolved but absorbed on the surface of starch particles, forms a thin layer that wraps around and separates the particles, preventing them from compacting too tightly, allowing air to easily penetrate and escape during the heating process. Fat also traps more air during the creaming process, resulting in more air pockets expanding. Cookie formulas with low-fat content make the dough less plastic and reduce particle mobility, requiring

Table 5. Analysis results of the effect of corn and moringa composite flour proportions on the sensory acceptance of cookies

Formula	Average sensory acceptance score of corn moringa cookies			
	Color	Texture	Taste	Aroma
F0	3,96±1.46 ^a	3,92±0.99 ^a	3,9 ±0.93 ^a	3,7 ±1.09 ^a
F1	3,50±0.93 ^a	4,2±0.82 ^a	3,9 ±0.74 ^a	3,3 ±0.99 ^a
F3	3,83±0.96 ^a	4,3± 0.82 ^a	4,0± 1.16 ^a	3,4±0.88 ^a
F5	3,83±1.05 ^a	4,1± 1.03 ^a	3,5 ±1.18 ^a	3,1±1.06 ^a
F7	3,88±1.03 ^a	4,0±0.81 ^a	3,9±0.88 ^a	3,3±1.42 ^a

Note: The same letters followed numbers in the same column indicate no significant difference according to DMRT at 95% confidence level

greater pressure during the sheeting process compared to formulas with high amounts of margarine. This causes the surface structure to become denser, forming relatively large cavities in the cookies. The density of the cookie structure is also indicated by the results of hardness testing, where the lower the amount of margarine used, the higher the hardness of the cookies.

The resulting taste of the cookies in all treatments is sweet, and there is no deviation in taste such as bitterness due to the addition of moringa leaf flour. The amount of sugar added to all treatments is 25%, which may mask the bitter taste of moringa leaf in the treatment with 7% moringa leaf flour. As a comparison, in the study by Medho & Mohamad (2021), the addition of 7% moringa leaf flour in corn bread with 40% wheat substitution significantly affected the hedonic value of the moringa taste. The lowest hedonic value was found in the treatment with 7% moringa leaf flour, which was 2.55, indicating that the panelists did not like the taste of the corn moringa bread, which was sweet and slightly bitter, because sugar was added to all treatments, namely 15%.

In Table 5, it is observed that the proportion of composite corn and moringa leaf flour does not significantly influence the hedonic value for aroma. The range of preference values is 3.1 – 3.7, indicating a decision by the panelists that the aroma of moringa leaf produced is average (neutral). The resulting aroma of the cookies is corn and moringa. The moringa aroma, which smells of raw moringa, has disappeared during the processing of raw moringa leaves into flour by blanching. This is different from the study by Augustyn *et al.* (2017), where the higher the addition of moringa leaf flour, up to 9%, the lower the organoleptic results for the aroma of moringa biscuits. The decrease in acceptance level towards the aroma of biscuits is due to the flour-making process being done without blanching.

4. CONCLUSION

The proportion of composite flour F7 (93:7) caused a faster initial gelatinization time, which was 8.53 minutes, and did not significantly differ from the proportions of composite flour F3 (97:3) and F5 (95:5), but differed significantly from the proportions of composite flour F1 (99:1) and F0 (100:0). The proportion of composite flour of corn and moringa leaves also significantly affected a significant decrease in peak viscosity, hot paste viscosity, breakdown viscosity, setback viscosity, and final viscosity values with increasing moringa leaf flour in the composite flour proportion. The proportion of composite flour of corn and moringa leaves also did not show a significant effect on sensory values for all attributes of color, texture, taste, and aroma, but physically had a significant effect on the color of cookies, which turned slightly greenish brown. Chemically, cookies produced from the proportion of composite flour of corn and moringa leaves in the formula F3 (97:3), F5 (95:5), and F7 (93:7) were higher and not significantly different in protein, crude fiber, and dietary fiber values.

ACKNOWLEDGEMENT

We would like to express our gratitude to the Ministry of Research, Technology, and Higher Education through the DIPA of the State Agricultural Polytechnic of Kupang for funding the research activities under the Applied Competitive Research Scheme for Fiscal Year 2021 under contract No. 03/P3M/SP DIPA.023.18.2.677616/2021, April 16, 2021.

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