Characteristics of yellow sweet potato flakes (*Ipomoea batatas* L.) with the addition of moringa leaf flour (*Moringa oleifera*)

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Abstract. Flakes made from yellow sweet potato flour are one of the products with the addition of moringa leaf flour to increase the added value of the two commodities. The purpose of this study was to characterize the chemical and organoleptic properties of yellow sweet potato flakes with the addition of moringa leaf flour and determine the best treatment. This research was designed using a Completely Randomized Design with the addition of 0%, 2%, 4%, 6%, 8% moringa leaf flour, and repeated twice. The results showed that the addition of 4% moringa leaf flour was the best treatment because it was following SNI, with chemical characteristics of 3.43% moisture content, 1.88% ash content, 7.24% fat content, 2.05% protein content, 80.54% carbohydrate content, 4.81% fiber content and organoleptic characteristics of color (3.93 like), taste (3.76 like), aroma (3.40 like), crispness (3.90 like), and overall (3.90 like).

1. Introduction

Sweet potato (*Ipomea batatas* L.) is the main source of carbohydrates after rice, maize, and cassava, and has an important role in the food supply and industrial raw materials. Among carbohydrates sources; especially rice, cassava, and corn, sweet potatoes are proven to have significant advantages and benefits for Indonesian in terms of high productivity and carbohydrates, their various varieties, relatively cheaper prices and have been known from generation to generation by Indonesian society [1]. Based on their colors, sweet potatoes are classified into 4 groups, namely purple, orange, white, and yellow sweet potatoes. The sweet potatoes that will be used in the study are yellow sweet potatoes.

Yellow sweet potato has a yellow tuber color, which contains quite a high beta-carotene and it also contains high fiber. Besides, it is also a source of vitamins and minerals that good enough to meet the public’s nutritional and health needs. Other nutritional contents found in sweet potatoes are protein, fat, and ash. The low utilization of sweet potatoes is due to the lack of post-harvest processing technology being applied. Sweet potatoes processing in Indonesia is relatively simple and the processing is still in the form of fresh sweet potatoes such as roasting, boiling, and frying [2]. Processing sweet potato into flour can produce a different form of processed food product so that it is easily applied in everyday life. The protein content of yellow sweet potato flour is considered low, flour with low protein content is difficult to stir, mix with yeast, and has low absorption. This type of flour is suitable for making flakes.

Flakes are a thin, round, brownish-yellow sheet food product and it is usually consumed with milk or
can be consumed directly as a snack [3]. This food is popular with the public because it is delicious, healthy, and practical in the presentation. Flakes can be made from a variety of food ingredients that contain carbohydrates and can be added with other nutritional sources such as protein to meet nutritional needs [4]. Therefore, one of the food ingredients that can be added as a source of protein is moringa leaves.

Moringa leaves are a part of the moringa plant that has been widely studied for its nutritional content and uses. Moringa leaves are very rich in nutrients, including calcium, iron, protein, vitamin A, vitamin B, and vitamin C [5]; [6]; [7]. Besides, Moringa leaves also contain various kinds of amino acids, including amino acids in the form of aspartic acid, glutamic acid, alanine, valine, leucine, isoleucine, histidine, lysine, arginine, phenylalanine, tryptophan, cysteine, and methionine [8]. The moringa leaves processing into moringa flour aims to increase shelf life, facilitate the processing of later products, so that it can provide added value for moringa [9]. According to Dahoklory [10], the protein content in Moringa leaf flour reaches 26.02%.

2. Methods

The ingredients used in making flakes are moringa leaf flour, yellow sweet potato flour, sugar, salt, water. The materials needed for chemical analysis are distilled water, NaOH, a mixed indicator (Bromcresol green), HCl, sulfuryc acid solution, ethanol.

This study used a Completely Randomized Design (CRD) with 5 levels of treatment as follows:

- T₀ = Without the addition of Moringa leaf flour
- T₁ = 2% addition of moringa flour
- T₂ = 4% addition of moringa flour
- T₃ = 6% addition of moringa flour
- T₄ = 8% addition of moringa flour

The percentage moringa flour addition in the treatment was based on the weight of yellow sweet potato flour.

Each treatment was repeated 2 times, so the total experimental unit was 5 x 2 = 10 experimental units with the following mathematical model:

\[ Y_{ij} = \mu + \alpha_i + \epsilon_{ij} \]  (1)

The research was conducted in 3 stages; the first stage is the process of making moringa leaf flour, the second stage is the process of making yellow sweet potato flour, and the third stage is the process of making sweet potato flakes. The process of making Moringa leaf flour [11] began with the selection of good raw materials to get a quality product. The leaves used were fresh Moringa leaves. After getting the fresh moringa leaves, then they were sorted and washed. Furthermore, the washed moringa leaves were drained to reduce the moisture in the moringa leaves, then dried using a cabinet dryer for 3 hours at 40°C. The results were then milled and then sieved with an 80 mesh sieve to obtain the moringa leaf flour.

Yellow sweet potato flour [12] is flour made from yellow sweet potatoes, sorted or selected to separate good yellow sweet potatoes from sweet potatoes that are not in good condition. Then they were peeled to separate the skin and the flesh after which the sweet potato meat was washed, and then thinly sliced to speed up the drying process. Then the yellow sweet potatoes were blanched to deactivate the enzymes and to get the fresh color of the product. The blanching lasted for 5 minutes at 82-93°C. After that, they were dried in the sun because it only takes ≤ 1 day. Then the sweet potatoes were milled using a blender, after that they were sifted to get fine grains using an 80 mesh sieve and it became yellow sweet potato flour.
3. Result and discussion
2.1. Chemical Test
3.1.1. Water Content. The results of the analysis showed that the addition of Moringa leaf flour had a significant effect on the water content of the flakes. The results showed that the more of the flour being added, the lower the water content of the flakes would be. This result was in line with the research of Putri et al [13], namely the more of the Moringa leaf flour being added to the canna cookies, the lower the water content will be. This was due to the increasing number of dry materials so that more water was bound and caused less water content of the flakes produced [14].
3.1.2. Ash Content. The results of the analysis showed that the addition of Moringa leaf flour did not significantly affect the ash content of the flakes. The results of the analysis of the lowest ash flakes content were found in the treatment without the addition of Moringa leaf flour with 1.55%, and the highest value...
was in the addition of 8% Moringa leaf flour with 2.29%. The ash content of the flakes in this study met the quality requirements of flakes based on SNI 01-4270-1996 with a maximum of 4.0%. Thus, it can be said that the ash content of the flakes with the addition of Moringa leaf flour fulfilled the quality requirements based on SNI.

3.1.3. Fat Content. The results of the analysis showed that the addition of Moringa leaf flour had a significant effect on the fat content of the flakes. The results of the analysis of the lowest fat content were found in the treatment without the addition of Moringa leaf flour with an average score of 6.69%, while the highest score of fat content was in the treatment of the addition of 8% Moringa leaf flour with 8.14%. The results showed that the more of Moringa leaf flour being added, the higher the fat content contained in the flakes product will be. This was due to the high-fat content of Moringa leaves, which is 2.52% [10].

3.1.4. Protein Content. The results of the analysis showed that the addition of Moringa leaf flour had a significant effect on the protein content of the flakes. The results showed that the more Moringa leaf flour was added, the higher the protein content of the flakes will be. This was due to the high protein content in Moringa leaf flour, which is 26.02% [10]. The increase in the protein content of the material was also closely related to the water content of the material. The protein content of the flakes in this study did not meet the requirements of SNI 01-4270-1996 which is a minimum of 5.00%.

3.1.5. Carbohydrate Content. The results of the analysis showed that the addition of Moringa leaf flour had no significant effect on the carbohydrate content of the flakes. The results of the analysis of the lowest carbohydrate content were found in the addition of 8% Moringa leaf flour treatment with 77.24%, while the highest carbohydrate content was in the treatment without adding Moringa leaf flour with 80.99%. The carbohydrate content of the flakes in this study met the requirements of SNI 01-4270-1996.

**Figure 2.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ Water Content

**Figure 3.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ Ash Content

**Figure 4.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ Fat Content

**Figure 5.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ Protein Content
3.1.6. Fiber Content. The results of the analysis showed that the addition of Moringa leaf flour had a significant effect on the fiber content of the flakes. The results showed that the addition of Moringa leaf flour would affect the crude fiber content of the flakes produced [14]. Moringa leaf flour has a high crude fiber content of 4.03% [10]. The fiber content of flakes in this study has met the requirements of SNI 01-4270-1996 which is 7.0%.

3.2. Organoleptic Test

3.2.1. Color. The results of the organoleptic test on the color of the flakes presented in Figure 8 showed that the average like value ranged from 3.33 to 3.93 which was descriptively on the hedonic scale close to like very much. From the distribution of these average values, it can be seen that the treatment without adding Moringa leaf flour and 4% addition of Moringa leaf flour treatment had the same average value, namely 3.93. The visual the appearance of the flakes, the higher of the addition of Moringa leaf flour, the color of the flakes tends to be a slightly yellowish brown.
3.2.2. Taste. The results of the organoleptic test presented in Figure 9 showed that the average value of the panelists' liking for the taste of flakes ranged from 3.20 to 3.76 which was descriptively on the hedonic scale close to like very much. The average value distribution for most favored by the panelists was in the treatment of adding 4% Moringa leaf flour with an average value of 3.76 (like). While the average value that panelists did not like was the addition of 8% Moringa leaf flour with an average value of 3.20. This shows that the more of the Moringa leaf flour being added, the level of preference for the taste decreases. This happened because, with high Moringa leaf flour, it will taste bitter.

3.2.3. Aroma. The organoleptic test results on the aroma of flakes shown in Figure 10 had an average value of 3.03-3.96 which was descriptively on the hedonic scale close to like very much. The more of the Moringa leaf flour that was given, the less favor of the flakes will be. The decrease in the level of favor for the aroma of flakes was due to the very dominant aroma of Moringa leaves. Moringa leaf flour has a very strong unpleasant aroma [15]; [16].

3.2.4. Crispiness. The results of the organoleptic test on the crispiness of the flakes with the addition of Moringa leaf flour were presented in Figure 11. It can be seen that the average value obtained ranged from 3.33 to 3.90 which is descriptively on the hedonic scale close to like very much. This was because the high water content will decrease the crispiness of the product. Therefore the moisture content of the 4% Moringa leaf flour addition treatment was very low, so the crispiness of the flakes product at 4% treatment increases.

3.2.5. Overall. The results of the overall organoleptic test in Figure 12 showed that the average value of the overall acceptance for flakes ranged from 3.46 to 3.90 which was descriptively on the hedonic scale to be close to like very much. The highest average value was found in the treatment of adding 4% Moringa leaf flour with a value of 3.90, this was presumably because the panelists liked flakes with bright color, non-bitter taste, no unpleasant aroma, and crispy. This assessment is in line with the opinion of [17], which states that the overall acceptance of food can be measured in terms of color, taste, aroma, and texture.

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**Figure 10.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ aroma

**Figure 11.** Effect of The Addition of Moringa Leaf Flour Treatment on Flakes’ Crispiness
4. Conclusion
Based on the results of the study, it can be concluded that the addition of 4% of Moringa leaf flour treatment was the best treatment because it is following SNI, with chemical characteristics of 3.43% moisture content, 1.88% ash content, 7.24% fat content, 2.05% protein content, 80.54% carbohydrate content, and 4.81% fiber content. Moreover, its’ organoleptic characteristics of color (3.93) like, taste (3.76) like, aroma (3.40) like, crunchiness (3.90) like and overall (3.90) like

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