

Preparation of biscuits from *Manihot esculenta* leaf flour

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Abstract: The *Manihot esculenta* (cassava) has an important representation, as it has a high nutrient content and versatility in technological use. The present study aimed to produce cassava leaf flour and use it in the production of biscuits. Cassava leaves were washed in and sanitized. Subsequently, the leaves were placed inside a solar dryer, previously cleaned and sanitized, and exposed to sunlight for 2 days (~30 h). After drying, they were ground in a domestic blender, with standardization of the granulometry by passing through a 14-mesh sieve, and the flour obtained was stored in an airtight container. Three preparation of the biscuits consisted of three formulations with different concentrations of cassava leaf flour: Standard (P, 0%), F1 (5%) and F2 (10%); replacing the proportion of flours. The analyses of cassava flour and biscuits were based on instrumental color, pH and total titratable acidity. The instrumental color parameters for cassava leaf flour were: $L^* 42.11 \pm 0.05$, $a^* -7.88 \pm 0.01$, $b^* 21.471 \pm 0.48$, $C^* 22.78 \pm 0.45$ and $^{\circ}h 110.25 \pm 0.40$, indicative of the presence of yellow and green pigments, in addition to low luminosity. The pH was 5.62 ± 0.40 , characteristic of low acidity. The biscuits showed statistical difference between them ($p < 0.05$) in all color parameters. The pH content of the biscuits ranged from 6.39 to 6.65, with no significant difference ($p > 0.05$). Regarding titratable acidity, it did not vary significantly ($p > 0.05$): 0.03 to 0.06 g citric acid 100 g^{-1} . This is a concise presentation of all the relevant points of the study. Biscuits are low-acid foods due to their low acidity content.

Keywords: technological use; solar dryer; *Manihot esculenta*; Cassava; production of biscuits

1. Introduction

The ability to cope with an ever-expanding global population and the growing lack of food availability increasingly challenges the achievement of food security. Access to adequate and healthy food for all, which is provided permanently and sustainably, is considered a problem today. With a predicted increase of 1.7 billion in the global population between now and 2050, humanity is placing increasing pressure on the finite resources used to produce our food [1] It is necessary to find alternatives to meet the need for food, and also sources of nutrients and minerals, to meet the diet. For example, cassava and its leaves [2].

Cassava is widely grown in tropical countries in the America, Africa and Asia. It is one of the oldest plants cultivated in Brazil, and it also contributes to eradicating hunger among people in poor regions of South America [3]. Widely cultivated throughout Brazil due to the plant's ability to adapt to places with varying temperatures and soils, even those poor in nutrients [4]. In addition to its significant economic importance, the cultivation of the tuber and the production of its derivatives, such as flour, are job-generating activities [5]. It is worth mentioning that cassava is rich in starch, making it an excellent nutritional source, since its consumption can

provide the body with high levels of carbohydrates and calories, providing the human body with more energy [6,7].

Leaves are an alternative source of protein. The amino acid profile of most species is comparable to that of soybeans, meat, fish and eggs, and is generally higher than the FAO essential amino acid standard, which further encourages their use in new preparations and processes. [8–11].

Cassava can be consumed in the form of fresh roots and other derivatives, such as starch, tapioca, puba, among others. Widely consumed in Brazil, in the state of Mato Grosso do Sul, table cassava is used especially in cooked form and accompanied by meat dishes. Its consumption reaches around 22 kg/inhabitant/year, which is higher than the national average [12].

However, cassava leaves, whose main chemical and nutritional components are found with significant values, mainly proteins and minerals, are still considered as waste and discarded. After dehydration, the leaf has an average of 21% crude protein, high fiber content, and B-carotene levels (provitamin A that can vary from 23 to 86 mg/100g of natural matter) and vitamin C levels of up to 419 mg/100g of natural matter [13].

Flour is a fine starch powder made from cereals and other staple foods. It is most commonly made from wheat and is the main ingredient in the production of bread and biscuits, which are staple foods in many countries [14]. However, the demand for good flour production has been a key economic issue, as there is a high demand for water, specialized equipment and a large area specifically for planting. According to the Pakistan Nutrition Journal, since cassava leaf flour has high nutritional values, it is seen as a good substitute for wheat in the production of such products.

In addition to being considered a source of great nutritional value for human and animal food, due to its specific agronomic characteristics, which allow its exploration not only due to technological conditions, but also because it presents a wide diversity of other possibilities for use and incorporation into new products, such as in the preparation of baked goods, especially biscuits. According to resolution RDC No. 263 of the National Health Surveillance Agency (ANVISA), biscuits or cookies are products obtained by mixing flour, starch or starches and other ingredients subjected to the process of kneading, cooking, and fermented or not [15,16].

Biscuits is a product consumed worldwide. Due to the various possibilities of shapes, sizes, types and flavors, the preference for the type of biscuit will depend on the age group, custom or even dietary restrictions [17].

According to the Brazilian Association of Biscuit, Pasta, Bread and Industrialized Cake Industries (ABIMAPI), in Brazil, biscuits were present in approximately 90% and in 2019 they had a per capita quantity of 7 kg/inhabitant. During the preparation process, biscuits receive less liquid than other types of biscuits, due to this characteristic, they have greater crunchiness [10]. In addition to being well accepted by all age groups, biscuits are products that are easy to store and have a long shelf life, being a good option for a quick snack [18].

Thus, the present work aims to obtain flour from cassava leaves and to make biscuits from this flour.

2. Material and methods

2.1. Preparation of the leaves flour

Cassava leaves were collected in the city of Coxim, State of Mato Grosso do Sul, Brazil. The ripe and fresh leaves were collected in the morning during the leaf development phase.

The leaves used were sanitized with water and sodium hypochlorite for a period of 30 minutes submerged in the solution. After this step, the leaves were placed to dry on aluminum trays, on a wooden bench, in an open place in contact with sunlight. After drying, they were crushed in a blender (Britania, Brazil), then stored in plastic polyethylene packaging for the production of biscuits [19].

2.2. Preparation of biscuits with cassava leaf flour

To make biscuits, cassava leaf flour was added in concentrations of 5% to 10% to replace wheat flour. Eggs, unsalted margarine, baking powder, brown sugar, granulated sugar, salt and vanilla were used. The quantities were defined after preliminary tests. The biscuits formulation is shown in **Table 1**.

The dough was divided into small portions of approximately 15 g and molded into circular shapes. The biscuits were baked in buttered aluminum molds in a conventional oven for 30 min at 180 °C. After this step, the biscuits were cooled to room temperature and packaged in low-density polyethylene.

Table 1. Preparation of biscuits with cassava leaf flour.

Ingredients	Standard	F1	F2
Wheat flour	100 g	95 g	90 g
Cassava leaf flour	0 g	5 g	10 g
Cristal Sugar	50 g	50 g	50 g
Chemical yeast	1.5 g	1.5 g	1.5 g
Brown sugar	50 g	50 g	50 g
Eggs	50 g	50 g	50 g
Butter	25 g	25 g	25 g
Salted	1.3 g	1.3 g	1.3 g

Fonte: Ferreira et al. [9], adapted.

2.3. Physicochemical analysis

For pH analysis, 10 g of the sample were weighed in a 250 mL beaker, and 100 mL of distilled water were added. The sample was stirred on a magnetic stirrer for 3 min and then left to rest for 5 min. The sample was transferred to a dry beaker and the pH was determined by inserting the potentiometer electrode (BlueLab 716441, Brazil) into the sample following the procedure described by AOAC. The pH was determined for the cassava leaf flour and the biscuits. Total titratable acidity value (TTA) was obtained through titration with NaOH, at 0.01 N of 0.1 of normality [20].

The parameters for the instrumental color were determined using a Konica Minolta colorimeter (CR-400/Cr-410), with a CIE system $L^*a^*b^*$ (Comission Internationale de L'Eclairage 1986). Readings were done at five points; after each one

the fruit was rotated in 90°. The results were expressed in L*, a* and b* values, that is, the L* values (luminosity or brightness) range from black (0) to white (100), the a* chroma values range from green (−60) to red (+60) and the b* chroma values range from blue to yellow, being from (−60) to (+60), respectively.

2.4. Sensory analysis

The sensory analysis was performed at the Federal Institute of Mato Grosso do Sul, Coxim campus. Acceptance tests were performed with 60 untrained judges, who received three samples coded with three digits. The evaluation form with sample acceptability test using a 9-point hedonic scale, ranging from 1 (very much disliked) to 9 (very much liked). The attributes evaluated on the form were appearance, color, aroma, texture, flavor and overall quality [19].

2.5. Statistical analysis

All analyzes were performed in triplicate and the results were presented by the mean ($n = 3$) and Standard Deviation (SD). The comparisons between the groups were submitted to Analysis of Variance (ANOVA) and when significant, they were compared using the Tukey's test at 5% probability of error.

3. Results and discussion

The characterization of cassava leaf flour is shown in **Table 2**. The color analysis of the raw materials, a parameter of great importance in food products, showed that cassava leaf flour had a strong presence of the b* chromaticity component (18.18 ± 6.39), which indicates the presence of yellow pigment, and of a* (-7.49 ± 0.75), a green pigment, in addition to low luminosity ($L^* = 42.11$) [21].

Table 2. Instrumental color and pH characterization of cassava leaf flour.

Sample	L*	a*	b*	C*	°h	pH
Flour	42.11 ± 0.05	-7.88 ± 0.01	21.37 ± 0.48	22.78 ± 0.45	110.25 ± 0.40	5.62 ± 0.02

¹ Values expressed as mean $\pm$ standard deviation. L* (Luminosity), a* (Green to red color parameter), b* (Blue to yellow color parameter), C* (Chromaticity) and °h (Color hue and color saturation). Equal letters in the same row indicate that the samples do not differ from each other ($p > 0.05$).

Color changes in flour mixtures were also reported by Kaminski et al. [22] who studied the incorporation of whole rye flour with wheat flour, in proportions (0 to 100%), and found a reduction in luminosity (92.85 to 82.01) with the proportional increase in whole rye flour.

Regarding chromaticity coordinates, when the value of +a* is positive it indicates a direction towards red, while a value of −a* suggests a direction towards green. Similarly, a positive value of +b* points towards yellow, while a value of −b* indicates a direction towards blue. The central point between these coordinates is achromatic and as the values of a* and b* increase and the point move away from the center, the color saturation increases [23].

The authors concluded that the increases in the chromaticity components a* (0.21 to 2.27) and b* (8.74 to 9.92) indicated a tendency from red to yellow, probably due to the higher concentration of dietary fibers, pigments, lignins and other compounds,

and structural components of differentiated coloration present in the outermost layers of rye grains and, consequently, in the whole flour of this cereal. Ferreira et al. [9], for spinach leaf flour, found lightness values ($L^* = 55.83$), which indicates a flour that is less dark than that of cassava. The authors reported a tendency towards green due to the parameter a^* (-3.03), the same occurs with cassava leaf flour, which also presented values tending towards green, indicating the presence of chlorophyll, a compound that has antioxidant activities and beneficial effects on the body.

The results of the instrumental color parameter of the biscuits are shown in **Table 3**. All formulations showed statistical differences between them ($p < 0.05$) for all color parameters. Formulation F2 presented a color tending towards dark green, with lower values of L^* and a^* ; formulation F1 also tended towards green coloration, but with less intensity. The incorporation of flour caused a darker coloration in the biscuit, observed by the lightness coordinate (F2 $L^* 39.55$). Torres et al. [24] observed similar behavior when replacing wheat flour.

Table 3. Instrumental color parameters of biscuits with cassava leaf flour.

Color parameters	Standard	F1	F2
L^*	57.51 ± 0.80 a	48.58 ± 1.45 b	39.55 ± 0.93 c
a^*	4.63 ± 0.17 a	-1.47 ± 0.05 b	-2.41 ± 0.11 c
b^*	29.67 ± 0.55 a	25.31 ± 0.53 b	18.75 ± 0.33 c
C^*	30.03 ± 0.55 a	25.35 ± 0.52 b	18.91 ± 0.34 c
$^{\circ}h$	81.13 ± 0.21 a	93.33 ± 0.13 b	97.33 ± 0.23 c

¹ Values expressed as mean $\pm$ standard deviation. L^* (Luminosity), a^* (Green to red color parameter), b^* (Blue to yellow color parameter), C^* (Chromaticity) and $^{\circ}h$ (Color hue and color saturation). Equal letters in the same row indicate that the samples do not differ from each other ($p > 0.05$).

Chroma (C^*) values close to zero indicate more neutral colors, such as white and/or gray [25]. When chroma approaches zero, the color tends to be less saturated and closer to neutral tones. This phenomenon is especially observed in shades of gray and variations of white, where the presence of colors is minimal or almost non-existent, resulting in reduced saturation. Observe values that vary from 18.91 to 30.03 for the chromaticity parameter, this is mainly associated with the incorporation of cassava leaves in the formulations, since the standard formulation had the lowest value (18.91).

Table 4. Total titratable acidity (TTA) and pH analyses of biscuits with cassava leaf flour.

Analyses	Standard	F1	F2
pH	6.65 ± 0.03 a	6.64 ± 0.02 a	6.39 ± 0.02 a
TTA (g citric acid/100 g)	0.03 ± 0.01 a	0.05 ± 0.01 a	0.06 ± 0.01 a

¹ Values expressed as mean $\pm$ standard deviation. F1: formulation with 5% cassava leaf flour; F2: formulation with 10% cassava leaf flour. Equal letters in the same line indicate that the samples do not differ from each other ($p > 0.05$).

The results of pH and total titratable acidity of the biscuits are shown in **Table 4**. The formulations did not show statistical difference between them ($p < 0.05$) for pH and total titratable acidity values. The biscuits are low acid foods due to their low acidity content. The presence of greater amounts of acidity in biscuits with higher leaf

concentrations is associated with the presence of organic compounds in the leaf, which confer acidity to it [3].

Titrateable acidity, expressed as the percentage of citric acid, the value found was similar to that obtained in Ferreira et al. [9] for biscuits made with baru pulp flour, which obtained values of 0.05 g citric acid/100 g. The low pH and higher acidity values allow greater stability of the food, as they interfere with microbial growth.

The results obtained with the sensory characterization of the product are presented in **Table 5**. Through the results, we can observe that all formulations were considered as accepted by averages above 7, but formulation F2 stands out, being considered the best accepted by the judges. This shows that the incorporation of the leaf did not leave a residual flavor to the product, but only positively accentuated the flavor and texture so characteristic of cookies.

Ferreira et al. [9], in the preparation of cookies with the addition of unconventional flours, observed a similar behavior. This can also be associated with the change in people's diet, mainly towards foods considered healthier, which have nutritional appeal.

Table 5. Averages of sensory attributes of biscuits with cassava leaf flour.

Attributes ¹	P	F1	F2
Appearance	8.4 ± 1.0 a	7.9 ± 0.8 a	8.1 ± 0.8 a
Color	7.9 ± 1.0 a	8.0 ± 0.3 a	8.2 ± 0.8 a
Aroma	7.3 ± 1.0 a	8.3 ± 0.4 a	8.7 ± 1.0 a
Texture	8.1 ± 0.9 a	8.2 ± 0.6 a	8.1 ± 0.5 a
Flavor	7.4 ± 1.0 a	7.4 ± 0.7 a	7.5 ± 1.1 a
Overall quality	8.0 ± 0.7 a	8.0 ± 0.7 a	8.4 ± 0.8 a

¹ Values expressed as mean ± standard deviation. P: Standard; F1: formulation with 10% taro flour; F2: formulation with 20% taro flour. Equal letters in the same line indicate that the samples do not differ from each other ($p > 0.05$).

4. Conclusion

Given the good results obtained, the cassava leaf flour had good results in the preparation of biscuits, with a color closer to light green. It was possible to verify that the biscuits at a concentration of 5% had an acceptable flavor, while at 10% they had a slight taste of leaves. However, in view of the above, it is concluded that, in view of the above, this study still has a lot to be explored. This research has a broad potential to obtain more knowledge about cassava leaves, which are now a food that is being included in human and animal nutrition and that their physical and chemical properties need to be further researched.

Conflict of interest: The authors declare no conflict of interest.

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