INVESTIGACIÓN e INNOVACIÓN en INGENERÍAS
ISSN2344-8652

Physicochemical characteristics and textural properties of the casabe

Características fisicoquímicas y propiedades texturales del casabe

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Recibido: 24/05/2023
Aceptado: 19/07/2023
Publicado: 17/10/2023

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Abstract

Objective: The objective of this research was to determine the effect of the casabe production process on the final characteristics of the product. For this purpose, three small family businesses were chosen from Ciénaga de Oro, Córdoba (Colombia). **Methodology:** Physicochemical and textural characterization of the casabe produced was carried out. Descriptive analysis of the texture was performed with a trained panel of tasters, evaluating attributes of hardness, fracturability, crispness, and cohesiveness. Instrumental analyses of texture were conducted with a texture analyzer to determine hardness and fracturability. **Results:** The results revealed differences between the artisan casabe in terms of physicochemical characteristics (moisture and carbohydrates), sensory texture, and instrumental texture (hardness). No correlation could be established between the texture data evaluated instrumentally and sensorially. The differences in the characteristics of the casabe produced in the small family business are due to the discrepancy between the production processes, giving each casabe specific qualities. **Conclusions:** casabe can be defined as a hard and fractured product when consumed. These attributes can be considered the primary tool when determining quality as they are important characteristics of consumer acceptance. However, instrumental texture (hardness and fracturability) does not correlate with sensory texture.

Palabras clave: artisan product, sensory profile, instrumental profile, hardness, crispiness.

Resumen

Objetivo: determinar el efecto del proceso de elaboración del casabe en las características finales del producto. Para ello se escogieron tres pequeñas empresas familiares de Ciénaga de Oro, Córdoba (Colombia). **Metodología:** se realizó la caracterización fisicoquímica y textural del casabe producido artesanalmente. El análisis descriptivo de la textura se realizó con un panel de catadores entrenados, evaluando atributos de dureza, fracturabilidad, crocancia y cohesividad. Los análisis instrumentales de textura se realizaron con un analizador de textura para determinar la dureza y la fracturabilidad. **Resultados:** se encontraron diferencias entre los casabes elaborados artesanalmente en cuanto a las características fisicoquímicas (humedad y carbohidratos), y texturales sensorial e instrumentalmente (dureza). No se pudo establecer correlación entre los datos de textura evaluados instrumental y sensorialmente. Las diferencias en las características del casabe producido en las diferentes empresas familiares se deben a la discrepancia entre los procesos de elaboración, confiriéndole a cada casabe cualidades específicas. **Conclusiones:** El casabe se puede definir como un producto duro y fracturado al ser consumido. Estos atributos pueden considerarse la herramienta principal al determinar la calidad, ya que son características importantes de la aceptación del consumidor. Sin embargo, la textura instrumental (dureza y fracturabilidad) no se correlaciona con la textura sensorial.

Keywords: producto artesanal, perfil sensorial, perfil instrumental, dureza, crocante.

Como citar (IEEE): E. Fuentes-Bedoya., J. González-Hernández., C. Denise De Paula., M. Simanca-Sotelo., y R. Andrade-Pizarro "Physicochemical characteristics and textural properties of the casabe". *Investigación e Innovación en Ingenierías,* vol. 11, n°2, 39-48, 2023. DOI: https://doi.org/10.17081/invinno.11.2.6449

Introduction

Cassava is one of the major staple food crops in many countries worldwide, it can be cultivated in both tropical and subtropical regions. In Colombia, cassava is grown throughout the national territory mainly on the Atlantic Coast of Colombia, where it is the primary source of income and food security for the population besides being part of the cultural and gastronomic identity [1, 2].

The main products derived from cassava are sour starch, which is used in the preparation of other foods; sweet starch, which has a wide range of industrial uses (food and non-food), and dry cassava for the production of balanced foods [3]. “Bitter” cassava has two cyanogenic glycosides in the roots and leaves (linamarin and lotaustralin) which generate hydrocyanic acid through hydrolysis [4]. During the manufacturing process of *casabe*, grating, extraction, and cooking techniques are combined which contribute to the reduction or elimination of these substances.

The *casabe* is native to the Caribbean region and is used as a substitute for bread in the Colombo-Venezuelan Llanos. It is a thin, circular cake toasted on fire and made of bitter cassava flour (See Figure 1); it has a simple flavor, is soft to the palate and ideal as an accompaniment for fish, poultry, and meat. It is considered a high-energy food product especially because of its high carbohydrate content, although the low protein content is a limitation from a nutritional perspective [5].

Figure 1. Casabe produced in Ciénaga de Oro, Córdoba (Colombia)

Source: Own elaboration

Artisanal food products have been of great interest when it comes to the study of their characteristics and potential, in this context, they can be defined as edible products made by hand. These foods have great cultural value, good taste, smell, and texture which makes them a feasible element in the strategy for rural development. It is necessary to consider that some of these products do not consider the existence of food product regulations that must be met to be marketed. The increase in demand for these products and their cultural and gastronomic contribution adds to their potential to become a feasible rural development tool and this has attracted the attention of the general population [6].

In Ciénaga de Oro (Colombia), *casabe* is produced traditionally by local families who have inherited the trade from their ancestors. The production process varies according to the producer, making the product not uniform. In the elaboration of *casabe*, the fundamental operation is the laying, which involves pouring and spreading the cassava flour on a hot plate for baking the cake. At the end of the process, a non-uniform circular product is obtained with different textural characteristics, such as hardness and fracturability. These measurements are used as an indicator for the quality of the finished product [7].

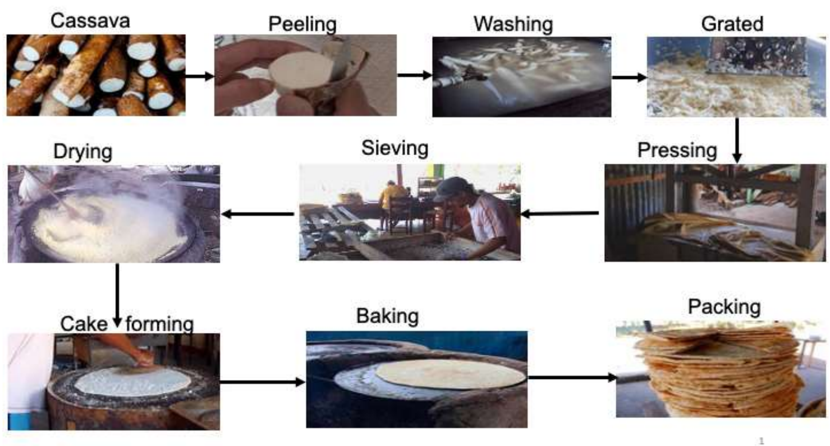
The texture of a product is a critical sensory attribute that can dominate its quality. Casabe must be crunchy and crisp, which determines its quality, a critical factor for its useful life, and can be rejected by consumers if it does not have these characteristics [8]. Texture can be measured by employing objective (instrumental) and intrinsic subjective (sensory) tests.

The purpose of this work is to determine the profile of the sensory and instrumental texture of the *casabe* produced by three family businesses in Ciénaga de Oro (Colombia) to establish a common language for both producers and consumers to describe the characteristics of the finished product.

Methodology

Samples of *casabe* were purchased from three family and artisan companies of the municipality of Ciénaga de Oro-Córdoba (Colombia). These were selected according to the production process, that is, companies with the same stages of the *casabe* elaboration process. The companies were coded as A, B, and C, to simplify their recognition. Figure 2 presents the *casabe* production process.

Figure 2. Flowchart of casabe production process



Source: Own elaboration

Physicochemical characterization of casabe

The samples were ground, sieved, and packaged in polyethylene bags and then analyzed. The physicochemical characterization of the *casabe* was carried out by determining moisture (925.10), ethereal extract (920.85), crude protein (960.52), ash (923.03), crude fiber (920.86), according to AOAC methodology [9], and total carbohydrates by difference.

The sensory texture of casabe

The descriptive sensory analysis was performed by texture profiling. The three treatments were evaluated by a panel of 20 trained tasters who provided a breakdown and description of the textural characteristics of the casabe. The panelists were selected according to their discriminative capacity ($p \leq 0.05$) and reproducibility capacity ($p \geq 0.05$).

For the survey of the descriptive attributes of the sensory texture of the *casabe*, the open discussion methodology was used in which the most relevant characteristics of the treatments were analyzed and described. After discussions to reach a consensus, the descriptive terms that were most relevant for characterizing the casabe texture were selected (Table 1). After selecting the most representative attributes, the minimum and maximum intensity values were established for each using examples with foods that fell within the two extremes of the characteristic.

Table 1. Physical and sensory definition of sensory attributes

Attributes	Physical definition	Sensory definition	Measurement technology
Hardness	Force required to achieve a deformation.	Force required to bite through the sample with the molars.	Placing the sample between molars and biting down evenly, evaluating the force required to compress the food.
Adhesiveness	Work needed to overcome the forces of attraction between the surface.	Force required to remove material that adheres to the mouth (usually on the palate) during the normal process of ingesting food or meal.	Placing the sample on the tongue, pressing it against the palate, and evaluating the force required to remove it with the tongue.
Fracturability	Force with which a material fractures or breaks. A product with a high degree of hardness and a low degree of cohesiveness.	Force with which the sample crumbles, cracks, or shatters.	Placing the sample between molar teeth and evaluating the force with which the food moves away from the teeth.
Chewiness	Energy needed to chew a solid food to a state ready to be swallowed: a soft, cohesive, and elastic product.	Time(s) required to chew the sample to a consistency suitable for swallowing.	Placing sample in the mouth and masticating at a constant force application, evaluating the time required to reduce the sample to a state ready for swallowing.
Crunchiness	They are perceived directly on the teeth and in this case, the food has considerable water content.	Crunchy foods are perceived by the vibration when biting into the ingredients (inner ear, teeth, and gums).	Placing the sample between the molar teeth evenly, biting down, and listening to the sound when biting down.
Cohesiveness	Minimum energy applied for the food to fracture, crumble, or crack.	Force with which the particles are bound, the limit up to which they can be deformed before breaking.	Placing the sample between molar teeth, compressing, and evaluating the amount of deformation before rupture.

Source: Own elaboration

Texture identification and description test

Once the descriptive attributes of the sensory texture of the casabe were selected, an attribute intensity test was performed using an unstructured scale of 9 cm in length, which was anchored at the ends with the terms weak and strong. The judges marked a horizontal line representing the intensity of each attribute studied.

A triangular test was conducted to establish whether there were differences (p≤0.05) between the three treatments. Two combinations of treatments A-B and A-C were prepared and formulated into trios considering the following combinations: AAB, ABA, BAA, ABB, BAB, and BBA for which different treatments were be selected. Each panelist was presented with a trio of samples whose combination was randomly chosen and the combinations of treatments were delivered in a balanced manner. The casabe samples were presented on 15.5 cm plastic plates, white coded with random three-digit numbers, and evaluated in triplicate by the 20 panelists.

Instrumental analyses of texture

Textural properties of the *casabe*, hardness and fracturability, were measured using a TA.XT Plus Texture Analyzer (Stable Micro System, UK) equipped with a 3-point bend rig (Figure 3) according to the methodology reported by Altan *et al*. [10]. The speed of the probe was 2 mm/s and the distance between the two support points was 20 mm. The *casabe* was cut in a square shape with sides of approximately 3.5 cm.

Figure 3. Determination of the instrumental texture of the casabe.

Source: Own elaboration.

Experimental design and statistical analysis

The study was carried out using a completely randomized outline with three *casabe* processing companies and three replications, totaling nine experimental units. The results were submitted to ANOVA in the form of averages of the treatments performed by the F and Tukey test (p≤0.05). All the analyses were performed using the Statistical Analysis System (SAS) version 9.1.

Results and discussion

Physicochemical characterization of casabe

Table 2 presents the results obtained from the physicochemical characterization of the *casabe* produced in Ciénaga de Oro, Córdoba (Colombia). The ANOVA reveals a significant difference (p≤0.05) only in the moisture, ethereal extract, and carbohydrates.

Table 2. Physicochemical analysis of casabes produced in Ciénaga de Oro, Córdoba (Colombia).

Parameters	Treatment A	Treatment B	Treatment C
Moisture (%)	1.73±0.01a	1.53±0.00b	1.33±0.01c
Ethereal extract (%)	0.62±0.01a	0±0.00b	0±0.00b
Crude protein (%)	1.24±0.05a	1.73±0.07a	1.30±0.02a
Ash (%)	1.98±0.05a	1.71±0.02a	1.84±0.10a
Crude fiber (%)	1.86±0.06a	1.51±0.03a	1.72±0.02a
Carbohydrate (%)	92.57±0.09c	93.51±0.02b	93.82±0.12a

** Means with different lowercase letters in a row are significantly different (p<0.05) by the Tukey's test.*

Source: Own elaboration

The samples of *casabe* presented moisture values between 1.33 and 1.73% with treatment A being the highest value (1.73±0.01%) and treatment C the lowest (1.33±0.01%). These low contents are reasonable since within the *casabe* elaboration process there are stages, such as the pressing that facilitate the extraction of a significant amount of the water content and the later baking and drying on hot plates, that help evaporate the remaining water present in the cassava flour. The differences between treatments could be caused by the variations between the technique used by the different producers during the manufacturing stages mentioned. The values found are lower than those reported for cassava bread (about 9.6%) produced by indigenous ethnic groups [11], *casabe* produced in different regions of Venezuela (9.9%) [12], and cassava flour and bovine plasma cookies which reported a moisture content of 4.30% [13]. These differences could be due to the discrepancy of the raw material between regions, in addition to the processing conditions, primarily the time, baking temperature, and drying of the product.

The treatments showed a low content of ethereal extract which was no more than 0.62%, this value is related to the almost non-existence of fat in the casabe root. Statistical differences were observed ($p \leq 0.05$) between treatments A with B and C, the latter two were statistically equal ($p \geq 0.05$). The value obtained for treatment A is very similar to that reported for *casabe* made in Venezuela (0.4%) [12], for cookies based on cassava flour and bovine plasma (0.62%) [13], for refined cassava flour (0.50%) [14], and cassava bread "*casabe*" (0.6%) [11].

The crude protein content did not present significant differences between the treatments of the companies evaluated ($p \geq 0.05$), presenting values between 1.24 and 1.73%, indicating that *casabe* does not constitute a good source of protein in human food. These results were similar to those reported for refined cassava flour (1.70%) [14], *casabe* made in regions of Venezuela (1.30%) [12], and cassava bread made by indigenous ethnic groups (1.20%) [11]. However, Benítez *et al.* [13] reported a protein content of 5.22% for cookies based on cassava flour and bovine plasma, this high value of protein is due to the addition of bovine plasma.

Regarding the ash content of the treatments, there were no statistical differences between them ($p \geq 0.05$), which is similar to what is reported in the literature for refined cassava flour [14]. These results are in agreement with those recorded by Infante *et al.* [12], with a percentage of over 1.40% in casabe made in different regions of Venezuela and with those of García *et al.* [11] who found 1.70% in cassava bread made by indigenous ethnic groups, while Benítez et *al.* [13] recorded a value of 1.99%.

The crude fiber present in the treatments ranged from 1.51 to 1.86%. Similar values reported for refined cassava flour were 1.80% [14] and, for *casabe* made by indigenous groups and different regions of Venezuela, a value of 1.7% was reported [12].

Regarding the carbohydrate content, the treatments showed statistical differences (p≤0.05), with values greater than 92.57%. With these results, it can be inferred that *casabe* has a good energetic potential, making it a suitable source of energy. When comparing these results with those of García *et al.* [11] on cassava bread made by indigenous ethnic groups, a similarity was evidenced since the latter reported a value of 87.3%.

The sensory texture of casabe

The panel of tasters was made up of 20 people aged between 17 and 25 who were all students from the Food Engineering program (University of Córdoba, Berástegui). They were previously trained in research and had also received training sessions to evaluate texture attributes.

Once the training sessions and evaluation of sensory attributes were completed, a consensus was reached at which point the texture profile was formed, selecting hardness and fracturability as the most representative characteristics in the *casabe* followed by crispness and cohesiveness. Statistically significant differences were determined (p≤0.05) between the three treatments for all the texture attributes evaluated. On the other hand, Tukey's test (p≤0.05) showed that none of the attributes studied had similarities between treatments, which leads to the inference that the process of making the *casabe* has a direct influence on its texture (Table 3).

Table 3. Descriptive attributes of the sensory texture of the casabe produced in Ciénaga de Oro, Córdoba (Colombia).

Treatment	Hardness	Fracturability	Cohesiveness	Crispness
A	3.35±0.24c	5.22±0.67c	9.94±0.77a	8.25±0.65a
B	6.48±0.83b	8.50±0.76b	4.18±0.59b	4.59±0.38b
C	11.44±0.52a	11.55±0.38a	1.63±0.36c	1.22±0.50c

** Means with different lowercase letters in a column are significantly different (p<0.05) by the Tukey's test.*

Source: Own elaboration

Treatment C reported the highest hardness value (11.44±0.52), while treatment A the lowest (3.35±0.24). It is possible that these discrepancies were influenced by the difference between the stages of the *casabe* production process, especially the baking and drying of the cake as these do not present a constant temperature during the entire process, making the water content affected which ultimately defines the hardness of the product. Considering the aforementioned, the results obtained for the hardness are in agreement since treatment C presented a value of 1.33% of moisture, a value lower than that found in treatment A (1.73%). Cueto and Pérez [15] reported that cookies made from cassava and wheat flour had high hardness values as more strength was required between the molars to compress it. Similarly, Soler-Martinez *et al.* [16] reported that there is significant hardness in all their wheat, bean, and sorghum biscuit samples due to low moisture content.

In case of fracturability, treatments C (11.55±0.38) and A (5.22±0.67) represented the highest and lowest value respectively, being significantly different ($p \leq 0.05$). This attribute is directly related to hardness; the higher the hardness, the higher the fracturability due to low moisture content and the application of a relatively small force on the molars resulting in fracture, crumbling, or cracking. Baked lemon cookies showed good fracturability which was related to the freshness of the product and its internal structure [8]. Furthermore, in cassava starch and chontaduro cookies, it was evident that fracturability was affected by the decrease in water in each formulation, making them more brittle as the percentage of water decreased [17].

Cohesiveness was higher for *casabe* from treatment A (9.94±0.77) and significantly lower for treatment C (1.63±0.36). This texture attribute is considered a good indicator that the cassava flour held together during the baking process [18]. In banana starch cookies, cohesiveness depended directly on fracturability [19]. Cookies based on whey flour showed high cohesiveness in all formulations because they used similar water content and the manufacturing procedure was standardized, making the product structure similarly fractured [20].

The crispness of the *casabe* was between 1.22 ± 0.50 and 8.25 ± 0.65 for treatments A and C, respectively. These values are expected as this attribute is closely related to the hardness; the harder the food, the less crunchy it is [20]. Crispness is considered to be a fundamental factor in establishing a sensory quality and depends on factors such as temperature and storage time of the finished product. Hough *et al.* [21] found in his study that cookies lost their crispness as water content increased. The results obtained in the triangular test showed differences between the treatments. (A-B and A-C), confirming the results obtained in the sensory profile test.

The instrumental texture of casabe

Table 3 shows the results of instrumental measurements of the hardness and fracture toughness attributes of casabe. Significant differences were observed ($p \leq 0.05$) between the averages of the treatments for hardness. This could be due to the heterogeneity of the raw materials used by the different companies evaluated and the conditions during the manufacturing process. Moreover, the internal structure of cassava flour also affects the hardness of the product obtained [22]. Wang *et al.* [23] evaluated cookies with 3% fiber from different sources and reported the highest hardness value in cookies containing more soluble fiber and lower moisture content. On the other hand, differences between the particle size obtained in the grating, pressing, sifting, cooking, and drying temperatures also influence the textural parameters evaluated.

Correlation between sensory and instrumental texture

When comparing the results of sensory and instrumental hardness and fracturability, no correlation was found between the two methods. Therefore, instrumental analysis cannot replace sensory analysis in the characteristics studied. This result could be due to, among other causes, the rigidity of the equipment for human jaws, calibration of the equipment, and differences in the size of the samples. The correlation of the sensory and textural tests depends on many factors, such as type and size of the sample, equipment, and tests used, among others. Jensen *et al.* [24] found no correlation between sensory and instrumental analysis for hardness and cohesiveness in bread with added cassava flour. Matos and Rosell [25] found a significant correlation for a limited number of instrumental analysis parameters and sensory texture attributes in gluten-free cookies. However, Gámbaro *et al.* [26], found that sensory texture attributes were well predicted by instrumental analysis for different types of cookies.

This result can be considered negative as a good correlation would imply the generation of valuable information that would lead the producer to search for instruments to measure the quality of the product to understand what the consumer perceives in the mouth when ingesting the food and to optimize and improve the instrumental methods to complete the sensory evaluation [27].

Conclusion

The handmade *casabe* produced in Ciénaga de Oro, Córdoba (Colombia) can be considered a good source of energy and an appropriate choice to include in the daily diet due to its high content of carbohydrates and low fat.

According to the profile of sensory texture, *casabe* can be defined as a hard and fractured product when consumed. These attributes can be considered the primary tool when determining quality, as they are important characteristics of consumer acceptance. Instrumental texture (hardness and fracturability) does not correlate with sensory texture, this leads to a lack of prediction of consumer response in terms of product quality acceptance and does complement the data obtained from sensory evaluation.

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