

Evaluation of physical and textural characteristics of pandebono

Evaluación de características físicas y texturales de pandebono

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Abstract

The pandebono is a traditional gluten-free product from Colombia made mainly with cassava sour starch, cheese and milk or water. The cheese is critical in its formulation, because it imparts suitable sensory and textural properties. In this study, these properties were evaluated on pandebono made from two types of cheeses, costeño cheese and white cheese. Texture profile analysis, firmness, crust fracture, and determinations of weight, volume and density were performed using a one-way analysis of variance. (sensory differentiation test of triangular type was performed to assess the overall flavor of the products. The firmness was higher in the pandebono made from costeño cheese because the crumb was more uniformity; whereas the crust fracture was higher in the pandebono made from white cheese, reflecting a greater crust thickness. There were not significant differences in texture profile analysis. The weight and volume were lower in pandebono made from costeño cheese, while the density was higher. The overall flavor of samples was different, mainly by the costeño cheese properties, which has a characteristic and salty taste.

Key words: Costeño cheese, gluten-free product, rheology.

Resumen

El pandebono es un producto libre de gluten típico de Colombia, elaborado principalmente con almidón agrio de yuca, queso y agua o leche. El queso es fundamental en su formulación, ya que le imparte al producto sus propiedades sensoriales y texturales características. En el estudio se evaluaron estas propiedades en pandebonos elaborados con dos tipos de quesos: costeño y blanco. Se realizaron análisis de perfil de textura, firmeza, fractura de la corteza y determinaciones de peso, volumen y densidad mediante un análisis de varianza de una sola vía. Para evaluar el sabor general se hizo una prueba sensorial de diferenciación de tipo triangular. La firmeza fue mayor en pandebono elaborado con queso costeño debido a que la miga fue más uniforme; mientras que la fractura de la corteza fue mayor en pandebono elaborado con queso blanco, reflejando un espesor de corteza mayor. En el análisis de perfil de textura no se encontraron diferencias significativas. Los pesos y los volúmenes fueron menores en pandebono elaborado con queso costeño, pero la densidad fue mayor. El sabor fue diferente, principalmente por las propiedades del queso costeño, el cual tiene un salado característico.

Palabras clave: Producto libre de gluten, queso costeño, reología.

Introduction

Pandebono is a bakery product obtained from fermented cassava starch and cheese as main components. According to the place of preparation, there are variations in its formulation, although it is common the use of flour or corn starch, eggs, plant oil and water or milk. These ingredients are mixed to form small portion for baking. The most outstanding characteristics of this product are the spongy texture, open crumbs, low density and fast hardening.

A product with similar characteristics to the ones of pandebono is produced in the Minas Gerais region, Brazil, which is known as cheese bread (pão de queijo, in Portuguese). As the pandebono, the cheese bread does not have an established quality standard neither a production technology or defined product, reason why it is in the market with products of the same denomination but, with very different characteristics (Minim *et al.*, 2000; Aplevicz, 2006).

Cassava fermented starch is an important constituent of pandebono, since it gives volume and porous crumbs with many cells containing air. Similarly, the cheese is a fundamental ingredient because it gives the characteristic aroma and taste, complements the crumbs structure and helps the texture of the final product (Pereira *et al.*, 2004).

Characterization studies for these kind of products, specially cheese bread, have been focused on the evaluation of density, specific volume, expansion index, compression resistance and analysis of the texture profile (Pereira *et al.*, 2010; Machado y Pereira, 2010a). Also, there are evaluations on the rheological profile and visco-elastic properties of the dough in the farinograph and texture analyzer, respectively (Machado and Pereira, 2010a; Machado and Pereira, 2010b). Pereira *et al.* (2010) evaluated the response when replacing curated cheese by ricotta cheese on the properties of cheese bread and found an increase in that an increase in the percentage of the last one in the formulation generates a product that is softer, less gummy not prone to fracture and, with a lower crust thickness than the one generated with curated cheese. In these works there were no diffe-

rences in the sensorial properties of the elaborated products with both cheeses, therefore is possible to replace the curated cheese with the ricotta type.

In Colombia is widely used the cheese called "costeño" which is fresh and with a salty taste between mild and strong. However, this cheese has the disadvantage that its sanitary quality is not the best due to the poor conditions of processing and storage, that lead to finding some pathogen microorganisms (Gallegos *et al.*, 2007). The objective of this research was to evaluate the physical and textural characteristics of the pandebono formulated with two types of cheese: costeño and White.

Materials and methods

Physicochemical analysis of cheeses

Physicochemical characteristics were determined for both costeño and white cheese. Activity of water (aw) was measured with a dew-point hygrometer at 25 °C (Aqualab serie 3TE, Decagon, Devices, Pullman, WA, USA) (Cortés *et al.*, 2007). pH was measured with a potentiometer by introducing the electrode directly in the cheese dough (Peláez *et al.*, 2003). Percentages of humidity, fat and salt were determined following the methodology proposed by Kosikowski (1977). The cheese percentage of humidity was determined by the drying in oven method, consisting on putting a 2 g cheese sample on a Petri dish to dry at 100 °C for 24 h in oven (U30, Memmert, Germany). The percentage of fat was determined by the modified method of Babcock. 9 g of grinded cheese were weighted on a butyrometer and 10 ml of water at 54.4 °C and 17.5 ml of sulfuric acid were added. Later, the butyrometer was subjected to centrifugation cycles of 5 min, 22 min and 1 min with additions of water at 76.7 °C between each centrifugation. Finally, the butyrometer was transferred to a water bath at 60 °C for 5 min to determine the fat percentage.

The percentage of salt in the cheese was determined using the modified method of Volhard. To 3 g sample of grinded cheese on a flask were added 25 ml of silver nitrate (AgNO₃) 0.1 N, 10 ml of nitric acid (HNO₃) and 50 ml of distilled water and it was heated till

ebullition under a gas extractor chamber. When the mix reached ebullition temperature 15 ml of potassium permanganate were added (KMnO₄) in 5 ml portions. Then, the mixed was cool down to room temperature and 2 ml of nitrobenzene and 2 ml of ferric alum were added separately. The flask content was agitated and titrated with potassium thiocyanate (KSCN) 0.1 N till getting a light red color. The percentage of salt was calculated using the equation 1:

$$\% \text{ Salt} = \frac{[(Ax B) - (Cx D)] \times 0.0585 \times 100}{M} \quad \text{Eq. 1}$$

where, A: silver nitrate volume (ml) added (25 ml), B: silver nitrate normality (0.1 N), C: potassium thiocyanate volume (ml) used for titration, D: potassium thiocyanate normality (0.1 N), M: amount (g) of simple used, 0.0585: sodium chloride milliequivalents.

Proximal analysis of the cassava fermented starch

Percentages of starch were determined (ISO 10520, 1997), ashes (AOAC 942.05, 2000), raw fiber (NTC 668, 1973), crude fat (NTC 668, 1973), humidity (ISO 6496, 1999), pH (potentiometer) and protein (Kjeldahl's method NTC 4657, 1999). Measurements were done in duplicate.

Absorption of water (I.A.A.) and solubility in water(I.S.A.) indexes

These indexes were determined by triplicate in cassava fermented starch according to the method proposed by Anderson *et al.* (1969) which consists in calculate by gravimetry the

amount of dissolved material and the proportion of absorbed water after agitation of a starch suspension at an established temperature. For that, on a centrifuge of 50 ml, a 2.5g a starch sample was placed with 30 ml of distilled water at 30 °C. Later, the tube was placed on a water bath at 30 °C. was agitated for 30 min and centrifuged at 3000 rpm for 10 min (Universal 320-R, Hettich, Germany). Supernatant was separated and the resulting gel was weighted to calculate I.A.A. (Equation 2). To calculate I.S.A., the supernatant was placed on a 30 ml beaker previously calibrated and dried out at 100 °C for 24 h till it reached constant weight. The soluble solids, or the supernatant dry weight, were used to calculate I.S.A. by the equation 3.

$$I.A.A \text{ (g/g)} = \frac{\text{gel weight}}{\text{sample weight (d.w.)}} \quad \text{Eq. 2}$$

$$I.S.A \text{ (\%)} = \frac{\text{supernatant dry weight}}{\text{sample weight (d.w.)}} \times 100 \quad \text{Eq. 3}$$

Preparation

To prepare pandebonos the following ingredients were used: costeño cheese, white cheese, cassava fermented starch, precooked corn flour, margarine, sugar, salt and UHT whole milk, bought at a local market. The formulations to prepare both kinds of pandebono are shown in Table 1. Initially, dry ingredients and margarine were mixed on a mixer (Professional Series 600-KP26M1XER, KitchenAid, St. Joseph, MI, USA). Then, milk was slowly added till getting a soft and homogeneous dough that was divided in 30 g portions and

Table 1. Raw materials to prepare pandebono.

Raw materials	Costeño cheese		White cheese	
	Amount (g)	Percentage (%)	Amount (g)	Percentage (%)
Cheese	300	40.1 %	300	42.7 %
Fermented starch	150	20.0 %	150	21.4 %
Corn flour	60	8.0 %	60	8.6 %
Margarine	30	4.0 %	30	4.3 %
Sugar	18	2.4 %	18	2.6%
Salt	-	-	9	1.3%
Milk	190.5	25.5 %	135	19.2%

manually molded with the help of a cylinder (diameter=47 mm, height 14 mm). Each pandebono was baked at 235 °C for 15 min on a gas oven (GFO-4B, Guangzhou Youjia Machinery Co.).

Weight, volume and density

Pandebono weight was determined on a precision balance (BL-6206, Shimadzu). Density was calculated using the weight:volume ratio. This ratio was obtained with the modified methodology proposed by Carrillo (2007) using the displacement method of millet seeds placed on a 250 ml beaker with 33 mm ratio. The procedure was the following: a fixed amount of millet seeds was placed in a beaker till a fixed height, then seeds were moved to another vase. Then, the pandebono was introduced in the beaker, the millet seeds were moved to the beaker and the distance from the fixed height till the top of the seeds was measured. The pandebono volume was calculated by the following equation.

$$V = \pi x r^2 x d \quad \text{Eq. 4}$$

where, V is the pandebono volume (ml), r is the beaker ratio (cm) and d is the distance measured (cm).

Texture properties

The texture of the pandebono samples was determined by puncture and compression tests and texture profile analysis (TPA) on a texture analyzer (TA-XT2i, Stable Micro Systems, Godalming, U.K.) using the Texture Expert Exceed version 2.64 (2002) software. Crust fracture was obtained by a penetration assay using a 2 mm cylinder probe (SMS P/2). The firmness of whole pandebonos formulated with both cheeses was determined by a uniaxial compression assay using a 100 mm cylinder compression platen (SMS P/100). TPA was performed compressing two times the whole sample with a 100 mm cylinder compression platen (SMS P/100) to obtain all the texture properties of hardness, elasticity and cohesiveness (Bourne, 2002). For the compression test and the TPA, sample and compression platen were lubricated with liquid paraffin to minimize friction effects. Parameter

on the analyzer were pre-assay velocity 2.0 mm/s, assay velocity 2.0 mm/s, post-assay velocity 5.0 mm/s, compression distance 15 mm and load cell 50 kg.

Sensorial analysis

A triangular test according to the NTC 2681(2006) policy was performed on a panel of 32 members to determine the perceptible sensory difference on general taste between both kind of pandebonos.

Statistical analysis

Experimental data were evaluated by one way analysis of variance (Anova) to determine the effect of the cheese type on the physical and texture characteristics of pandebono. For data management the software Statgraphics Centurion XV version 15.2.05 (2006) was used with the minimum significant difference method (DMS) and a confidence level $\alpha = 0.05$. For the sensorial response test data the same confidence level was used. The statistical analysis of that test follows a binomial distribution, requiring 16 hits on a 32 members panel in order to get a perceptible difference between samples (NTC 2681, 2006).

Results

Raw material analysis

Physico-chemical analyses on cheese type are show in Table 2. According to the results on fat and humidity percentage, costeño cheese can be classified as fat and hard, while the white cheese is fat and semi-hard (Ministerio de la Protección Social de Colombia, 1989). Costeño cheese had a lower humidity content than the one found by Rodríguez and Novoa (1994) (45-47%) and a higher fat content (23-25%). Chávez-Acosta and Romero-Naranjo (2006) found in costeño cheese samples produced in different fabrics a humidity range between 35.7-42.7% and fat 19-26%. Other important aspect is the high salt content present in costeño cheese (3.5%), which is a characteristic of this product. Salt has the function of strengthen taste and ensure a long shelf life. The salt percentage for costeño cheese found in this study agrees with the findings of Chávez-Acosta and Romero-Naranjo (2006), although the pH (5-5.2) differs

Table 2. Physico-chemical characteristics of evaluated cheeses.

Characteristic	Costeño cheese	White cheese
Humidity (%)	40.0 ± 0.01 a*	49.7 ± 0.01 b
a _w	0.9 ± 0.004 b	1.0 ± 0.001 b
pH	5.4 ± 0.05 a	6.4 ± 0.01 b
Fat (%)	31.0 ± 1.41 a	26.5 ± 0.71 a
Salt (%)	3.5 ± 0.06 a	1.0 ± 0.04 b

* Values in the same row followed by different letters are significantly different (P < 0.05).

from the value of 6.5 found by these authors.

Cassava fermented starch is indispensable to prepare different bakery products, among them, pandebono. The proximal composition, I.A.A and I.S.A., are shown in Table 3. To highlight are the high starch content associated with the botanical source and the low pH due to the fermentation step involving acid-lactic bacteria. Cadena *et al.* (2006) found in cassava fermented starch different values to the ones presented in this study: ashes (0.23% - 0.54%), fat (0.13% - 0.59%) and protein (0.82% - 1.28%); however, for humidity (8.04% - 12.35%), fiber (0.23% - 1.06%), and carbohydrates (starch 85.22% - 90.28%) the values were similar. These values agree with the ones determined in Brazil for this product, humidity (14%), maximum ashes (0.5%) and minimum starch content (80%) (Diniz, 2006). Variation in humidity content could be due to the exposition time and the weather conditions during the drying process under the sun. Differences in protein content are associated with the fermentation time because the developed microorganisms can pro-

Table 3. Proximal composition and I.A.A. and I.S.A. of cassava fermented starch.

Characteristic	Value
Starch (%)	87.8 ± 2.1
Ashes (%)	0.05 ± 0.02
Raw fiber (%)	0.30 ± 0.04
Gross fat (%)	0.05 ± 0.04
Humidity (%)	10.7 ± 0.05
Protein (%)	0.40 ± 0.2
pH	3.63 ± 0.09
I.A.A. (g/g)	3.30 ± 0.05
I.S.A. (%)	0.70 ± 0.07

I.A.A.= Water absorption index. I.S.A.= Water solubility index.

duce protein metabolites (Diniz, 2006). Variation in ashes and fiber content could be attributed to the starch contamination with foreign materials like dust, insects and soil from the environment, including the water used on the extraction process (Cadena *et al.*, 2006).

Cassava fermented starch I.A.A. and I.S.A. were between the reference values established by Aristizábal and Sánchez (2007), 0.82 and 15.52 g gel/g for the first one and, 0.27 and 12.32% for the second one. Rodríguez *et al.* (2006) found I.A.A. of 4.66, 5.00 and 5.44 g gel/g for cassava flour samples obtained from precooked parenchyma resting at low temperatures (5 °C, -5 °C and -20 °C) respectively; similarly they found I.S.A. of 12.49, 10.79 and 13.18% for the same flours. Machado *et al.* (2010) observed I.S.A. values between 0 and 0.3% in suspensions of 30 °C fermented starch from Brazil.

Weight, volume and density

These characteristics are important on bakery products preparation, since they are related with the amount of cells with air present in the interior. In pandebono and cassava fermented starch products an expansion occurs while cooking dough implying gas production and volume increase (Mestres *et al.*, 1996). In Table 4 are shown these characteristics of the pandebono formulated with both cheeses. Significant differences (p < 0.05) were observed between pandebonos. Weight and volume were higher with white cheese, and density was higher with costeño cheese. White cheese affected weight due to its high water content. On the other hand, salt could act directly with the liquid component of the formulation causing water retention and reducing its availability during evaporation in the baking process. Volume, distribution of air cells and global shape were more uniform in the costeño cheese pandebono, while in the white cheese pandebono there were some bumps and cracks.

Costeño cheese favors the expected characteristics in this type of products, like homogeneous air cell distribution in the crumps and better crust aspect (Pereira *et al.*, 2004), this is due to the interaction among components, mainly protein and fat with cassava starch. For its higher fat content, this cheese could

act inhibiting hydration and volume gain of the starch granules avoiding amylose leaching, as it happens in cereal starches (Mitolo, 2006). Additionally, density depends on the two previously mentioned characteristics but, in bakery products is associated more with volume. A low volume implies higher density and particularly for bread wheat flour means poor carbon dioxide retention in the gluten network. Pandebono made with costeño cheese has a lower volume and showed a higher density when compared to white cheese pandebono. Pereira *et al.* (2010) did not find differences on cheese bread when replacing curd cheese by ricotta cheese; according to the authors this result was due to the fact that they calculated the ingredients used in function of the content of fermented starch. Clareto *et al.* (2006) found that the use of a protein concentrate as a substitute for 100% of fat did not affect the cheese bread density.

Texture properties

Texture in bakery products is of great importance since it is mainly associated with freshness and the aging process on product that have two layers or zones, an exterior one called crust and an interior one or crumb (Cauvain, 2004). Crust fracture, firmness and texture profile analysis (TPA) of the pandebonos formulated with both cheeses are on Table 4. In this study, the crust fracture and whole product firmness were different between both types of pandebono ($p < 0.05$), being bigger the fracture in the white cheese pande-

bono, while the firmness was higher in the costeño cheese type. Fracture results indicate that a thicker crust was achieved in white cheese pandebonos, indicating that a larger amount of water migrated from the center towards the surface during baking, which generated an increase in thickness by different layer with larger and more irregular air cells. When these kinds of cells are formed in the crust a higher fracture force is required (Altamirano-Fortoul *et al.*, 2012).

Product firmness is associated with the uniform distribution of air cells or alveoli in the pandebono crumbs. In this study, the pandebono prepared with costeño cheese was more uniform and had a higher percentage of air cells of smaller size, which favors firmness increments. This result is better explained by the higher fat content in this type of cheese. When the fat crystals are melted during baking, the fat-liquid interphase generates extra material in interphase for the bubbles surface allowing expansion without breakup. Therefore, a high number of small bubbles can survive during baking and, contribute to a better crumb quality and uniformity (Brooker, 1996).

Machado and Pereira (2010b) observed different values for compression resistance in cheese bread with different formulations and elaboration processes. For the breads made with milk and blanching, the results were similar to the ones of this study (16.64 N). Hardness, elasticity and cohesiveness of both pandebonos were similar at population level. However, is important to notice that the hard-

Table 4. Physical and texture properties of pandebono formulated with costeño and white cheese.

Properties		with costeño cheese	with white cheese
Physical	Weight (g)	23.8±0.2 a*	24.4±0.4 b
	Volume (cm ³)	57.4±0.9 a	61.1±0.9 b
	Density (g/cm ³)	0.4±0.0028 a	0.4±0.0034 b
Texture	Crust fracture (N)	1.4±0.06 a	1.6±0.07 b
	Firmness (N)	19.3±2.68 a	15.9±0.45 b
	TPA – hardness (N)	17.1±2.93 a	15.0±0.91 a
	TPA – elasticity	0.8±0.03 a	0.8±0.03 a
	TPA – cohesivity	0.4±0.01 a	0.4±0.03 a

* Values in the same row followed by different letters are significantly different ($P < 0.05$).

ness had a high coefficient of variation (CV=14.1%) making difficult the interpretation of results. Pereira *et al.* (2010) found elasticity and cohesiveness values to the ones of this study using ricotta cheese in cheese bread preparation.

Sensorial analysis

In the sensorial analysis test there were 22 hits, concluding that there were difference ($p < 0.05$) in general taste of both pandebonos. Some participants state that costeño cheese presents a strong and salty characteristic taste; others found differences in texture. These observations agree with the results obtained for texture analysis that showed costeño cheese pandebono was firmer and has a thinner crust with a lower fracture level.

Conclusions

- The results of this study showed that there is an effect of the cheese type on the physical and texture characteristics of pandebono. These characteristics define sample quality and are related to size, amount and distribution of air cells in the product.
- When comparing both formulations of pandebono it can be concluded that the costeño cheese product allows crumbs with uniform air cell sizes, giving more firmness and hardness to the product, and generating a strong sensorial difference in taste and texture.
- Costeño cheese affects the perceived properties by the consumer, being fundamental for pandebono preparation.

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References

Altamirano-Fortoul, R.; Hernando, I.; and Rosell, C. M.

2012. Texture of bread crust: puncturing settings effect and its relationship to microstructure. *J. Texture Studies*, doi:10.1111/j.1745-4603.2012.00368.x
- Anderson, R. A.; Conway, H. F.; Pfeifer, V.F.; and Griffin, E. L. 1969. Gelatinization of corn grits by roll - and extrusion - cooking. *Cereal Sci. Today* 14(1):4 - 12.
- Aristizábal, J. and Sánchez, T. 2007. Guía técnica para producción y análisis de almidón de yuca. Mejía, D (ed.). Boletín de Servicios agrícolas de la FAO. 163:137.
- AOAC (Association of Official Analytical Chemist). 2000. *Official Methods of Analysis*. 14 Ed. Arlington, EE.UU.
- Aplevicz, K. S. 2006. Caracterização de produtos panificados à base de féculas de mandioca nativas e modificadas. Master Thesis on Food Science and Technology. Universidade Estadual de Ponta Grossa. Ponta Grossa, Paraná, Brasil. 131 p.
- Bourne, M. C. 2002. *Food Texture and Viscosity: Concept and Measurement*. Academic Press, 2nd Ed., Nueva York. 427 p.
- Brooker, B. E. 1996. The role of fat in the stabilization of gas cells in bread dough. *J. Cereal Sci.* 24:187-198.
- Cadena, M. P.; Villarraga, E. C.; Luján, D. E.; and Salcedo, J. G. 2006. Evaluación de la agroindustria del almidón agrio de yuca (*Manihot esculenta* Crantz) en Córdoba y Sucre. *Temas Agrarios* 11(1):43 - 53.
- Carrillo, A. 2007. Evaluación del uso de antimicrobianos sobre la estabilidad de pan parcialmente horneado almacenado en refrigeración. Undergraduate Thesis on Food Engineering. Universidad de las Américas Puebla. San Andrés Cholula, Puebla, México. 77 p.
- Chávez-Acosta, A. E. and Romero-Naranjo, A.A. 2006. Diagnóstico de las condiciones microbiológicas y fisicoquímicas del queso costeado producido en el municipio de Sincé Sucre (Colombia). Undergraduate Thesis. Universidad de Sucre. Sincelejo, Sucre, Colombia. 103 p.
- Clareto, S. S.; Nelson, D. L.; and Pereira, A. J. 2006. Influence of a protein concentrate used as a fat substitute on the quality of cheese bread. *Braz. Arch. Biol. Technol.* 49(6):1019 - 1025.
- Cauvain, S. P. 2004. Improving the texture of bread. En: Kilcast, D. (ed.). *Texture in food solid foods*. Woodhead Publishing Ltd. Cambridge-England. Vol. 2:432 - 450.
- Cortés, R. M.; García S., A.; and Suarez, M. H. 2007. Fortificación de hongos comestibles (*Pleurotus ostreatus*) con calcio, selenio y vitamina C. *Vitae* 14(1):16 - 24.
- Diniz, I. P. 2006. Caracterização tecnológica do polvilho azedo produzido em diferentes regiões do Estado de Minas Gerais. Master Thesis on Food Science and Technology. Universidade Federal de Viçosa. Viçosa, Minas Gerais, Brasil. 103 p.
- Gallegos, J.; Arrieta, G.; Máttar, S.; Poutou, R.; Trespalacios, A.; and Carrascal, A. 2007. Frecuencia de *Listeria* spp. en quesos colombianos costeos. *Rev. MVZ Cordoba (Colombia)* 12(2):996 - 1012.

- Icontec (Instituto Colombiano de Normalización y Certificación). 1973. NTC 668, Alimentos y materias primas. Determinación de los contenidos de grada y fibra cruda. Icontec. Bogotá D.C. 5 p.
- Icontec (Instituto Colombiano de Normalización y Certificación). 1999. NTC 4657, Alimento para animales. Determinación del contenido de nitrógeno y cálculo del contenido de proteína cruda. Método Kjeldahl. Icontec. Bogotá D.C. 11 p.
- Icontec (Instituto Colombiano de Normalización y Certificación). 2006. NTC 2681, Análisis Sensorial. Metodología. Prueba Triangular. Icontec. Bogotá D.C. 17 p.
- ISO (International Organization for Standardization). 1997. Native starch. Determination of starch content. Ewers polarimetric method. ISO International Standard (ISO), no. 10520. ISO, Genova.
- ISO (International Organization for Standardization). 1999. Animal feeding stuffs. Determination of moisture and other volatile matter content. ISO International Standard (ISO), no. 6496. ISO, Genova.
- Kosikowski, F. V. 1977. Cheese and fermented milk foods. Edwards Brothers Inc., 2nd ed., Ann Arbor, Michigan. 448 p.
- Machado, A. V.; and Pereira, J. 2010a. Efeito do escaldamento nas propriedades tecnológicas e reológicas da massa e do pão de queijo. *Ciênc. Agrotec.* 34(2):421 - 427.
- Machado, A. V.; and Pereira, J. 2010b. Perfil reológico de textura da massa e do pão de queijo. *Ciênc. agrotec.* 34(4):1009 - 1014.
- Machado, A. V.; Araújo, F. M.; and Pereira J. 2010. Caracterização física, química e tecnológica do polvilho azedo. *Rev. Verde* 5(3):01 - 06.
- Mestres, C.; Rouau, X.; Zakhia, N.; and Brabet, C. 1996. Physicochemical properties of cassava sour starch. En: Dufour, D.; O'Brien, G.M. ; and Best, R. (eds.). Cassava flour and starch: progress in research and development. CIAT, Cali, Colombia. p. 143 - 149.
- Minim, V. P.; Machado, P. T.; Canavesi, E.; and Pirozi, M. R. 2000. Perfil sensorial e aceitabilidade de diferentes formulações de pão de queijo. *Ciênc. Tecnol. Aliment.* 20(2):154 - 159.
- Ministerio de la Protección Social de Colombia. Resolución 01804 (3, febrero, 1989). Reglamentación parcial del título V de la Ley 09 de 1979. Bogotá, D.C. 1989. 9 p.
- Mitolo, J. J. 2006. Starch selection and interaction in foods. En: Gaonkar, A. G. and McPherson, A. (eds.). Ingredient interactions effects on food quality. Taylor and Francis Group, LLC. United States of America. p. 139 - 165.
- Peláez, P.; Fresno, M.; Díaz, C.; and Darias, J. 2003. Caracterización físico-química de quesos frescos elaborados con leche de cabra en la isla de Tenerife. *Ciênc. Tecnol. Aliment.* 4(2):103 - 108.
- Pereira, J.; Ciacco, C.F.; Vilela, E. R.; and Pereira, R. G. 2004. Função dos ingredientes na consistência da massa e nas características do pão de queijo. *Ciênc. Tecnol. Aliment.* 24(4):494 - 500.
- Pereira, P. A.; Ramos, T. M.; Gajo, A. A.; and Gomes, U. J. 2010. Viabilidade da utilização de queijo tipo ricota na elaboração de pão de queijo. *Ciênc. Rural* 40 (11):2356 - 2360.
- Rodríguez, A.; and Novoa, C. 1994. Guía para producir quesos colombianos. Santafé de Bogotá Banco Ganadero. Universidad Nacional de Colombia ICTA, Santafé de Bogotá. 140 p.
- Rodríguez, E.; Fernández, A.; Alcalá, L.; and Ospina, B. 2006. Reología de suspensiones preparadas con harina precocida de yuca. *Ing. Des.* 19:17 - 30.
- Statgraphics Centurión XV© 2006 by StatPoint, Inc. Version 15.2.05 1. 1982-2007. <http://www.statgraphics.com>.
- Texture Expert Exceed 2002 by Stable Micro System version 2.64. <http://www.stablemicrosystems.com>.