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**Research Article**

# Evaluation of Physical, Physico-Chemical and Sensorial Properties of Cottage Diabolines and Diabolines Obtained Under Standard Conditions of Process

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**Abstract:** In this study, physicochemical (moisture, ash, protein, fat, fiber and carbohydrates), physical (specific volume, pH and hardness) and sensorial properties (preference testing with untrained sensory panels) were evaluated in cottage Diabolines and Diabolines obtained under standard conditions the process. A completely randomized experimental design with three replicates was applied, it was analyzed the data with ANOVA and Tukey test ($p<0.05$). Results showed that cottage Diabolines and Diabolines obtained under standard conditions did not have significant differences in ash, fiber, carbohydrates, pH, hardness and lightness. They were found significant differences in moisture, fat, protein, specific volume and color (h, a* and b*) in the samples evaluated, but not in the sensorial testing. Production of Diabolines obtained under standard conditions helps to control the most important variables in the process and final product homogeneity; which are part of the requirements in the Colombian Technical Norms (NTC 1241) and contributein a higher protein and lower fat content than the cottage Diabolín.

**Keywords:** Baked product, cassava, hardness, homogeneity, starch

## INTRODUCTION

Diabolín is a type of snack food, a small crunchy sphere ate in the states of Córdoba and Sucre (Colombia); its main ingredient is native cassava starch (*Manihot esculenta* Crantz). There are no quality standards neither process parameters established for this traditional product; it is a typical cottage food and has different characteristics from one region to another. The basic ingredients are native and bitter cassava starches, cheese, milk, eggs, salt and margarine; this was mixed to form the dough then small balls are made and baked up to get the desired product (Aristizábal and Sánchez, 2007).

According to the definition of the World Customs Organization (1997), you can call "handmade" any product elaborated entirely by hand or using manual or mechanical tools with the constant intervention of a craftsman, which are also made without quantity restrictions. The main disadvantage is the lack of uniformity of the finished product, even though the same craftsman used the same design.

Never two pieces are exactly equal, which means lack of uniformity among 2 units of the same product; these disadvantages represent a problem for rural producers, mainly in emerging economy countries affected by the global market and the difficulties to struggle against big companies, its cutting-edge technologists and financial differences (Barkin, 2001; Boucher and Requier-Desjardins, 2005). It is likely that, in this global market, cottage food could disappear if handcraft producers do not satisfy the current regulation requirements (Domínguez-Lopez *et al*., 2011).

Developed countries, such as the United States, use cottage food to boost tourism and economic growth (USDA, 2006); the European Union promotes the rural development of its less-favored nations throughout its strongly-fixed traditions to reduce the differences between the north and center countries (Cantarelli, 2000).

Although cottage food represents a viable strategy to achieve rural development, technological variables of the production process must be considered, homogeneity of the volume produced and originality of this (Tregear, 2003). Miyagishima (2005), Secretary of the Codex Commission, pointed out that "when products have a quality standard, the opportunities to reach a global well-known may improve. Standards help not the only market in the region, but quality in regions out of the origin" That is why some cottage

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food has been focused on research to improve quality and survive in the global market (Domínguez-Lopez *et al*., 2011). It is necessary to identify the main characteristics of the products of each region, by characterizing their processes, knowing their variables and making them more competitive (Cantarelli, 2000).

The goal of this study was to evaluate the physical, physicochemical and sensorial properties of cottage Diabolines and Diabolines obtained under standard conditions the process. Thus, it can generate a product with high quality, uniformity and more competitive in the global market. Furthermore, due to the nature of their raw materials, Diabolín can be considered a "gluten-free product," which is, nowadays, an advantage globally, especially for people with celiac diseases (Sapone *et al*., 2012; Witczak *et al*., 2016).

In the US, the candy and bakery industry make up 46% of gluten-free products (Witczak *et al*., 2016); therefore, the diabolin could be competitive in this market; but it requires more research to guarantee high production volumes, homogeneity and quality in its processes.

## MATERIALS AND METHODS

It was developed this study in the Unit Operations Pilot Plant ate the Universidad de Sucre, campus Los Pericos (Colombia); also, in the Food Engineering Program labs at the Universidad de Córdoba, campus Berástegui (Colombia). Cottage Diabolín´s samples were obtained from the municipality of San Juan de Betulia (Sucre, Colombia) because this place is one of the most well-known for the quality and tradition in the production of Diabolín. Table 1 describes the formulation of the standard diabolin.

Table 1: Formulation of standard Diabolín

| Ingredients | % (p/p) |
|---|---|
| Native cassava starch | 43.46 |
| Milk | 30.79 |
| Colombian coast cheese | 18.58 |
| Bitter cassava starch | 3.10 |
| Egg | 1.98 |
| Margarine | 1.55 |
| Salt | 0.54 |

The ingredients were mixed in a food mixing machine (SINMAG SM-101; accessory: balloon), the dough was molded into a spherical shape, then they were baked in a convection oven (PIRON PF6004D, P524RUD-digital) with three continuous phases: 250°C (2 min), 190°C (3 min) and 150°C (35 min).

It was analyzed the pH by mixing 15 g of sample in 100 mL of distilled water according to AOAC 945.42 (2012); it was determined the specific volume (mL/g) through Ziobro *et al*. (2012). It was determined hardness with a texture analyzer (EZ TEST SM-500N-168, Shimadzu) by the firmness test, it was applied a uniaxial compression up to 50% of high and velocity of 60 mm/min. This was calculated from the force vs. time; it was analyzed the data with the software RheoMeter Software Copyright 1997,98 (C). In all cases, experimental units were placed over the inferior plate and submitted to the respective compression (AACC, 1998). It was measured the color with a colorimeter (Colorflex EZ 45, HunterLab®) with a diameter of 1.5 cm; it was used "illuminate D65" as a reference system. The samples were mushed in a ceramic mortar; it was used CIELab scale to determine the parameters: L* (lightness), h (hue) and values of a* (green (-a*) to red (+a*)) and b* (blue (-b*) to yellow (+b*)). The colorimeter was calibrated with a standard white plaque (L* = 94.8; a* = -0.78 and b* = 1.43) before each measure series (Hasbún *et al*., 2009).

Also, they have evaluated the physicochemical properties according to AOAC (2012): Moisture (925.10), fat (920.85), ash (923.03), protein (920.87), fiber (962.09) and carbohydrates (CHO) by to the Eq. (1):

$$\%CHO = [100 - ("\%moisture + \%fat + protein + ash + fiber)] \quad (1)$$

It was made the sensory evaluation throughout a paired preference test (Anzaldúa, 1994), these needed 46 habitual consumers of Diabolin (students, professors and campus's staffs), between the ages of 16 and 56. Each panelist tested samples from each treatment y these were compared among them; the results were analyzed with a two-tailed test (Roessler *et al*., 1978).

A completely randomized experimental design with three replicates was applied, these were used two treatments (Diabolin and standard Diabolin cottage); it was analyzed the data with ANOVA and it was made a Tukey's an honest significant difference. It was tested normality and homogeneity of variances in all cases; it was used the software Statgraphics Centurion 16.1.15 (XVI), testing version, to analyze the data.

## RESULTS AND DISCUSSION

Means comparison of Physical parameters between treatments ($p<0.05$) showed that cottage Diabolín had higher specific volume (4.92 mL/g) and hue value (h) (73.95) than standard Diabolín, which had higher values of a* (10.85) and b* (35.26). Hardness, pH and Lightness (L) did not show significant differences between treatments (Table 2).

A high specific volume in the cottage Diabolin indicates an increase air intake in the dough during the mix and expansion during the baking (Esteller and da Silva Lannes, 2005).

The cottage Diabolin is traditionally baked in clay ovens (using pieces of wood as fuel), these have capacity usually of 10 plates (50×30 cm) and the

Table 2: Means comparison of the physical parameters for cottage Diabolín and standard Diabolín

| | Treatments | |
|---|---|---|
| Parameters | CD | SD |
| Hardness (N) | 110.89±9.24a | 97.67±3.82a |
| pH | 5.59±0.23a | 5.24±0.08a |
| Specific vol. (mL/g) | 4.92±0.03b | 3.97±0.05a |
| h | 73.95±0.40b | 72.14±0.47a |
| L | 68.37±1.10a | 69.42±0.68a |
| a* | 8.89±0.10a | 10.85±0.48b |
| b* | 30.96±0.42a | 35.26±0.46b |

*CD: Cottage Diabolín; **SD: Standard Diabolín; Means with different letters in the same row, indicate significant differences ($p<0.05$)

Table 3: Means comparison of bromatological parameters in a cottage and standard Diabolín

| | Treatments | |
|---|---|---|
| Parameter | CD* | SD** |
| Moisture (% p/p) | 4.77±0.18a | 6.62±0.16b |
| Ash (% p/p) | 3.72±0.07b | 3.43±0.03a |
| Protein (% p/p) | 5.67±0.13a | 7.76±0.35b |
| Fat (% p/p) | 15.04±1.35a | 9.56±0.98b |
| Fiber (% p/p) | 1.36±0.54a | 0.88±0.32a |
| Carbohydrates (% p/p) | 69.52±0.94a | 71.74±1.62a |

*CD: Cottage Diabolín; **SD: Standard Diabolín; Means with different letters in the same row, indicate significant differences ($p<0.05$)

product residence time is of 60 min approximately; while the "standard Diabolin" was baked in an electric oven with 4 plates (repeated word) and the option to vary the time and temperature of the process, which allowed to obtain a product with homogeneity in shape and size. Yan *et al.* (1997) pointed out that properties of the product can also be affected by the starch granule size; which depends on the technology applied in the starch extraction. Furthermore, amylose content, origin, type of starch and genetic factors affect starch functional properties; which have effects in the volume, hydration and process yields (Abebe *et al*., 2015). According to Witczak *et al*. (2016), starch plays a fundamental role in the food matrix of bakery products; where process conditions and properties significantly affect final product properties.

The great valuate of the hue value (h) for cottage Diabolín indicate a lighter yellow color than the standard Diabolín, which had a red-yellow color. This is a contrast with a* and b* values, which were higher in the standard than in the cottage Diabolín. The superior values in b* were with the standard Diabolín, which represents a more intense yellow color than the cottage Diabolín.

The hardness is one of the primordial quality parameters in baked products with high influence in consumer's acceptance (Silva *et al*., 2009). There were no significant differences among the applied treatments, which shows that changes in both processes overall, did not change the product´s quality and acceptance. This is an advantage for producers due to the possibility to standardize their operations.

The standard diabolín had the highest values moisture (6.62% w/w) and protein (7.76% w/w), while cottage diabolín had big values for ash (3.72% w/w) and fat (15.04% w/w). But, carbohydrates and fiber did not show significant differences among treatments. (Table 3).

There are no regulations about the quality parameters for Diabolín as a cottage product. However, it can be comparable to other milling products. For instance, in this study, the NTC 1241 (2007) for cookies were used in order to compare the results obtained. Thus, moisture content in both types of Diabolín was according to the NTC 1241 (<10%). Data are according to other studies reported; Díaz and Hernández (2012) obtained cassava starch cookies with a moisture content between 4.19 and 5.11%. Mesías *et al.* (2010) reported moisture between 5.5 to 6.5% in whole toasted cookies. Primo-Martin *et al*. (2008) reported moisture contents between 9.6 and 15.6% in toasted rolls biscuit with thick and thin structure. Soto *et al.* (2016) evaluated Diabolines formulated with modified cassava starch and the moisture content was between 3.92 and 6.58% p/p.

A low moisture aids the product conservation under ambient temperature, which helps to maintain low the microbial charge (Belloso and Velázquez, 2008). Additionally, it represents an advantage to storage and shelf life (Esteller and da Silva Lannes, 2005; Benítez *et al*., 2008). Moreover, a low moisture allows the desired texture in this type of products, which makes it crunchier than others (Velásquez *et al*., 2014).

A higher protein content, in standard Diabolín, can be associated with more cheese and eggs into de formulation than the cottage Diabolín. This is an important nutritional advantage due to the protein function in the human metabolism. Protein content in both treatments satisfy the minimum requirements (≥3% p/p) in the NTC 1241, but it is inferior to the reported by Aparicio (2002) in a dough made with nixtamalized sorghum (11.25 and 12.22%). Likewise, the protein content was below in cheese bread (10.40%) and cookies (8.08%), according to Belloso and Velázquez (2008).

A low-fat content in the standard Diabolín is a favorable characteristic facing the current trends in nutrition associated with less fat in food consumption; furthermore, it strength the consumer preferences for traditional, local and natural products (Domínguez-Lopez *et al*., 2011).

The sensorial test showed no significant differences between the cottage and standard Diabolín ($p<0.05$); overall, consumers did not detect differences, which opens the viability to adopt the process standardization on traditional Diabolines in Colombia.

## CONCLUSION

Diabolín production under standard parameters, improve the control of the most primordial variables and its effects on the homogeneity of the final product, which satisfy the NTC 1241. Moreover, standard

Diabolín had higher protein and lower fat content than the cottage Diabolín, which is a benefit in the nutritional properties of the product. Even though that some of the quality parameters of standard Diabolín such as moisture, protein, fat, specific volume and color presented significant differences with cottage Diabolín; they were not detected sensorial differences by consumers, as well not as in properties of fiber, carbohydrates, pH, hardness and lightness properties.

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## CONFLICT OF INTEREST

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