

Microbiological, physicochemical and sensory evaluation of different brands of commercial peanut candy paçoca

RESUMO

Paçoca is a peanut-based candy, typical of the Brazilian culture. It is associated with some religious traditions that occur seasonally, but the consumption occurs throughout the year. In this study, four commercial brands of paçoca were analyzed for microbiological aspects, centesimal composition, instrumental color, sensory characteristics and labeling. In the microbiological tests, no relevant contamination was identified, and the centesimal characterization showed low variability among the brands. The sensory analysis showed a relevant acceptance of all brands and the instrumental color analysis indicated different aspects that can be considered in the quality control of the candy, such as color and the yellowish aspect, which may vary according to the peanut roasting process. Therefore, in this work, attributes of paçoca responsible for its acceptance and popularity in the Brazilian culture are showed.

KEYWORDS: labeling, sensory attributes, acceptance, traditional Brazilian candy.

Gabriel do Nascimento Santos¹
nascimento.gabriel.gns@gmail.com
orcid.org/0000-0003-0781-2055

Bianca Novaes da Silva¹
biancanovaes1910@gmail.com
orcid.org/0000-0002-7974-6336

Ícaro Fier¹
icarofier@gmail.com
orcid.org/0000-0001-7301-1809

Beatriz Altarugio Galdini¹
beatriz.agaldini@gmail.com
orcid.org/0000-0002-0906-5199

Isabella Ciarrocchi²
isabellaciarrocchi@gmail.com
orcid.org/0000-0002-6290-8124

Marta Helena Fillet Spoto²
martaspoto@usp.br
orcid.org/0000-0001-9219-6343

Sandra Regina Ceccato-Antonini¹
antonini@ufscar.br
orcid.org/0000-0002-0723-1704

Maria Teresa Mendes Ribeiro Borges¹
mtmrborg@ufscar.br
orcid.org/0000-0002-1115-3112

Simone Daniela Sartorio de Medeiros³
sisartorio@gmail.com
orcid.org/0000-0001-6455-8319

Marta Regina Verruma-Bernardi¹
verruma@ufscar.br
orcid.org/0000-0003-1375-0938

Vínculos Institucionais:

1. Universidade Federal de São Carlos, Araras, São Paulo, Brasil
2. Universidade São Paulo, Piracicaba, São Paulo, Brasil
3. Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brasil

INTRODUCTION

The peanut-derived product “paçoca” is a traditional Brazilian candy. It has an indigenous origin evidenced by its nomenclature, which is derived from the Tupi “pa’soka”, which means “crushing with the hands”, an allusion to the way it was produced – punched in a pestle. Initially salty, the paçoca candy has served as food for miners, and over the years the recipe has been improved, modified and industrialized (FERREIRA, 1986).

An easy-to-prepare candy, paçoca production occurs throughout the year, while its commercialization and consumption are considered seasonal, with the highest peak of sales during June and July (NEVES *et al.*, 2023). This increase may derive from the context of traditional religious festivals that happen in this period.

The paçoca candy is mainly composed of peanuts (the main ingredient), sugar, salt and manioc or corn flour. The ingredients may vary in proportion according to the recipe and are responsible for the sensory characteristics expected by the consumers (LEMOS JÚNIOR *et al.*, 2016). Paçoca contains 487 kcal in 100 g of peanut, and is mainly composed of lipids (26.1 g), proteins (16 g) and carbohydrates (52.4 g) (TACO, 2011).

The abundance of essential nutrients in peanut composition together with increased moisture, caused by rain in the post-harvest drying period and storage in humid conditions, provides ideal conditions for microbial growth (LIMA *et al.*, 2012). Peanut roasting is a critical point for microbiological control. Nonetheless, high fat content, low water activity and presence of sucrose in peanut confectionery products act as heat-protecting agents for *Salmonella* (CARMINATI *et al.*, 2016). Studies have been conducted aiming at the microbiological characterization of peanuts and derivatives (LIMA *et al.*, 2012; FREITAS *et al.*, 2014; CARMINATI *et al.*, 2016).

The microorganisms present in food reveal precious information about the hygiene and food safety conditions of the entire production process. The Brazilian National Health Surveillance Agency (ANVISA) works together with industries to promote the control of these and other contaminants in food, establishing standards and limits and providing quality and safety to the population (FELTES *et al.*, 2017). Furthermore, according to the International Commission of Microbiological Specifications of Foods (ICMSF, 1984), the number of mesophilic

microorganisms found in foods is a quality indicator of cleaning, disinfection, temperature control, transport and storage throughout the industrial process.

Several microorganisms use peanuts as substrate for growth. The most common microorganisms in peanuts are filamentous fungi, *mainly Aspergillus parasiticus* and *Aspergillus flavus*, which are widely known for producing aflatoxins and are considered critical points in the quality control of paçoca. Aflatoxins are toxic metabolites that have carcinogenic, mutagenic, teratogenic and immunosuppressive properties, and can be harmful to humans depending on the dosage and frequency of ingestion (LIMA *et al.*, 2012; FREITAS *et al.*, 2014). Therefore, the microbiological control at all stages of paçoca production regarding these and other pathogenic microorganisms is essential to ensure great product quality.

In the food industry, besides technological and microbiological characteristics, the sensory analysis is a complementary methodology to assess the food quality in order to guarantee the final acceptance of the product by the consumers. Sensory techniques such as discriminatory, descriptive, preference and hedonic tests are widely used (RUIZ-CAPILLAS; HERRERO, 2021). Sensory analysis can be useful to drive marketing decisions concerning not only to the product positioning with respect to competitors, but also market segmentation, customer relationship management, advertising strategies and price policies (IANNARIO *et al.*, 2012).

Another important tool for guaranteeing the quality of paçoca is the packing label. The main functions of packing labels present in food products are to inform the consumer about product features and help to sell the product. Information related to consumer's safety and protection has gained emphasis, and due to ethical and philosophical reasons, their insertion in product packages is mandatory (production method, presence or absence of ingredients, presence of allergenic components, and genetically modified ingredients), guaranteeing the right of information to the consumer who considers buying the product (CHEFTEL, 2005).

Paçoca has great economic, cultural and nutritional importance, and hence, ensuring sensory quality, as well as its composition, is essential for consumer preference and safety. Therefore, the aim of the present work was to evaluate the microbiological, physicochemical, labeling and sensory characteristics of four paçoca commercial brands, in order to analyze which nutritional and sensory

factors are the most responsible for their preference and acceptance by consumers. The relevance of this work is in the emphasis on the quality of the product in terms of its nutritional and microbiological composition as well as its sensory characteristics, aiming both at serving the consumer and the development of products of greater interest to the market.

MATERIAL AND METHODS

All experiments conducted in this study were evaluated and accepted by the University Ethics Committee with the following CAAE number: 19980919.2.0000.5504.

RAW MATERIAL

Four brands of the paçoca candy (named A, B, C or D) marketed in the Araras, State of São Paulo (Brazil), were evaluated. The criteria used for the choice of the paçoca brands were the information on the package label, such as manufacturing date and expiration date, same batch and characteristic format of cobblestone, individually packaged and containing 20 g each. All samples had a similar manufacturing date and expiration date.

MICROBIOLOGICAL ANALYSIS

The paçoca brands were analyzed regarding the number of colony-forming units (CFU) of molds and yeasts and total aerobic mesophilic bacteria following the methods described by Silva *et al.* (2010), by pour-plate technique in acidified Potato Dextrose Agar (Kasvi®) and Plate Count Agar (Kasvi®), respectively. The incubation temperature and time were 35 °C/2 days for bacteria and 30 °C/5 days for fungi. Total coliforms and *E. coli* numbers were estimated using 3M™ Petrifilm™ Plates. The analyses were performed in duplicate in four plots of each paçoca brandy.

CENTESIMAL COMPOSITION

For the determination of moisture, the samples were weighed (around 3.0 g) and heated in an oven (Fanem®) at 105-110 °C until a constant weight was reached

(AOAC, 1992). The ash content of the samples was determined by gravimetric measurement, in which an initial sample mass of approximately 3.0 g was incinerated in a muffle furnace heated at 600 °C (AOAC, 2005), and the protein content was determined by the Kjeldahl method (AOAC, 1995). Lipid extraction was performed with ethyl ether using the equipment Soxhlet (IUPAC, 1979), with the immersion of samples of approximately 0.5 g in the ether solution for 4 hours, and after the evaporation of the reagent, the reboilers of the equipment were weighed. All experiments were performed in triplicate, with three repetitions and four plots.

INSTRUMENTAL COLOR ANALYSIS AND SENSORY ANALYSIS

The colorimeter of Konika Minolta (model CR400s) was used to evaluate instrumental color. Luminosity (L^*), which varies from the darkest ($L^*=0$) to the brightest ($L^*=100$), was measured, as well as value a^* , which represents the color variation from red ($+a^*$) to green ($-a^*$), and value b^* , which represents a color variation from yellow ($+b^*$) to blue ($-b^*$) (CIE, 1976). The paçoca samples (triplicates of each brand) were placed into a Petri dish of five centimeters in diameter and a height of two centimeters.

Sensory tests were conducted at the Sensory Analysis Laboratory in individual cabins with white light. The paçoca samples were coded with three digits and one unit of each brand was served. Firstly, for the ranking test (ABNT, 1994), the attributes were selected from a previous analysis, considering that each attribute had sensory importance for consumption and product purchase. Sixty evaluators were invited for the test, who showed availability, interest, and had no health problems or allergies concerning any product ingredients. For the difference ranking test, the attributes evaluated were: color, brightness, sweet aroma, peanut aroma, sweet taste, peanut taste, salty flavor and homogenous texture.

In a second step, a preference ranking test was performed, where the evaluators were asked to order in ascending order: (a) preference to purchase paçoca according to the product; (b) preference for the brand; and (c) preference for the paçoca considering brand and price together.

In the third stage (global acceptance test), the consumers were instructed to complete a structured hedonic scale of seven points (1 - extremely disliked; 2 - disliked a lot; 3 - moderately disliked; 4 - neither liked nor disliked; 5 - I liked it moderately; 6 - I liked it a lot; 7 - I extremely liked it) (MEILGAARD *et al.*, 1999). The samples were randomly presented in a monadic manner. General data were also collected from the evaluators regarding the frequency of consumption, gender, and whether the consumer taster had a diagnosis of diabetes or peanut allergy, for safety reasons.

STATISTICAL ANALYSIS

The data on instrumental color, centesimal and acceptance test composition were submitted to the analysis of variance (ANOVA) test, considering a completely randomized design, with four treatments and three repetitions. When necessary, the Tukey's test was applied. The interpretation of the data obtained in the ranking test was performed according to the Friedman's test (NEWELL; MacFARLANE, 1987). For centesimal composition, the results obtained in the laboratorial determinations were compared to the labels of the paçoca brands.

RESULTS AND DISCUSSION

In this study, the influence of sensory attributes and nutritional characteristics of four commercial brands of the Brazilian peanut candy paçoca on consumers' preference were evaluated. The microbiological analysis and centesimal composition complemented the evaluation, aiming to perform a complete analysis of the aspects of paçoca that are responsible for its popularity in the Brazilian culture.

The microbiological analysis (Table 1) followed the current Brazilian food legislation (2001) for the parameter *E. coli*, whose limit is 10 CFU g⁻¹. The number of mesophilic bacteria observed in the four brands varied from 75 CFU g⁻¹ (brand D) to 4.4 x 10³ CFU g⁻¹ (brand C). Regarding mold and yeast numbers, all brands displayed low concentrations of these microorganisms, ranging from 4 CFU g⁻¹ (brand D) to 15 CFU g⁻¹ (brand C). No *Aspergillus* sp. colonies were observed in the samples.

Table 1 - Microbiological analysis of the paçoca brands under study.

Brand	<i>E. coli</i> (CFU g ⁻¹)	Mesophilic bacteria (CFU g ⁻¹)	Molds and yeasts (CFU g ⁻¹)
A	< 10	8.9 x 10 ²	10
B	< 10	2.6 x 10 ³	7.5
C	< 10	4.4 x 10 ³	15.0
D	< 10	7.5 x 10 ¹	4.0

Source: Own Authorship (2020)

Fecal coliforms are naturally present in the intestinal microbiota of animals, including humans. Their presence may indicate problems in the hygienic habits of the production chain. *E. coli* is the main indicator of fecal contamination, and its presence is related to sanitization problems and increased health risk (NKERE *et al.*, 2001). Among the brands analyzed, the number of *E. coli* was below the detection limit of the method (Table 1), which was also below the limit established by Brazilian law, which indicates a good sanitization of the production process.

In several foods, aerobic mesophilic bacteria are utilized as indicators of hygienic conditions in the production process. However, they are part of the natural microbiota of peanuts and derivatives. Nevertheless, it is possible to suggest that the production of brand D was under more hygienic conditions in comparison with other brands and all products were within the pre-established standards of microbiological quality regarding the number of mesophilic bacteria.

Fungi are the most relevant contaminants in peanuts. Among them, the fungi of the species *A. parasiticus* and *A. flavus* are in greater prominence because they are major producers of aflatoxins, toxic metabolites with carcinogenic, mutagenic, teratogenic and immunosuppressive properties, which can be harmful to human health depending on the dosage ingested (LIMA *et al.*, 2012; FREITAS *et al.*, 2014). Colonies of the fungus *Aspergillus* usually have a grainy appearance with the color ranging from black, dark green to dark brown (ORDAZ, 2003; THATHANA *et al.*, 2017). No colonies with such characteristics were observed, however, the absence of *Aspergillus* colonies does not rule out the presence of toxin.

The threshold value of 5 x 10³ CFU g⁻¹ for mold and yeast number in paçoca and derivatives was established in Brazil in 1997 but in 2001, this value was modified to “unlimited” (BRASIL, 2001). All the brands here analyzed fit satisfactorily to Brazilian legislation.

The paçoca brands here analysed showed low microbiological contamination, indicating that good harvest, transport, drying and storage conditions were followed. Thus, the microbiological data guarantee that the paçoca brands followed good hygienic practices throughout the production chain.

Table 2 presents the results regarded the centesimal analyses of the commercial brands compared to the composition exhibited in the package labels.

Table 2 - Centesimal composition of the paçoca brands compared to the composition exhibited in their labels.

Attribute	Reference	Brand				CV (%)
		A	B	C	D	
Moisture (%)	This study	1.10 a	1.46 a	0.60 b	0.67 b	43.00
	Label	-	-	-	-	-
Ash (%)	This study	1.65 a	1.83 a	1.65 a	1.38 b	8.06
	Label	-	-	-	-	-
Fiber (%)	This study	-	-	-	-	-
	Label	4	4	4	5	-
Carbohydrates (%)	This study	34.66 bc	32.98 c	46.74 a	36.15 b	3.21
	Label	48.5	55	55	55	-
Lipids (%)	This study	55.13 a	51.25 a	53.24 a	56.14 a	12.31
	Label	28	24	24	25	-
Proteins (%)	This study	6.37 ab	6.92 a	4.57 b	6.35 ab	20.86
	Label	17.5	13	13	15	-
Sodium (mg)	This study	-	-	-	-	-
	Label	185	273	273	105	-
Unit price (R\$)	-	1.10	0.15	0.82	0.65	-
	This study	1.10 a	1.46 a	0.60 b	0.67 b	43.00

Values followed by different letters in the line differ statistically by the Tukey's test ($p \leq 0.05$)

Source: Own Authorship (2020)

Brands A e B showed higher moisture contents (1.10 and 1.46%), while brands C e D showed lower moisture contents (0.60 and 0.67%). Concerning to ashes, brands A, B and C displayed higher concentrations than brand D. Ash content is directly related to the content of insoluble solids present in food, such as metals, mineral salts or impurities present in the samples (ARAÚJO *et al.*, 2006).

The fiber content of paçoca displayed in the brand labels (4 to 5%) is relatively low mainly due to the low concentrations of total fiber in peanuts. The paçoca candy is essentially composed of sugar and peanuts, usually in proportions close to 1:1; therefore, it was expected that the carbohydrate contents in paçoca (sugars in their majority) were close to the sum of the protein and lipid contents (the main constituents of peanuts). However, the mean carbohydrate content in the paçoca

brands evaluated in this study was 37.63%, while the mean sum of protein and lipid contents was 60% of the total weight of the candies.

Sodium content expressed in the brand labels ranged from 105 to 273 mg, for brand D and for brands B and C, respectively. This parameter was not analysed in the present work. For unit price, brand A presented the greatest value (R\$ 1.10), while brand B presented the lowest value among all brands (R\$ 0.15).

The results of the instrumental color analysis show that brand A presented the highest values for L (Table 3), indicating a lighter and more yellowish-colored product compared to the other brands. On the contrary, brand D presented the darkest and most orange color in relation to the others. There was no significant difference for the parameter a^* (Table 3), indicating a reddish and homogeneous color among the samples.

Table 3 - Mean of the instrumental color analysis of the paçoca brands.

Variable	Brand				CV (%)
	A	B	C	D	
L	68.5 a	64.9 b	63.9 b	59.1 c	1.4
a^*	5.7 a	5.9 a	6.1 a	6.4 a	8.5
b^*	31.2 a	30.3 a	28.5 b	27.5 b	1.8

Values followed by different letters in the line differ statistically by the Tukey's test ($p \leq 0.05$)

Source: Own Authorship (2020)

Studies relating the values of L with the qualities of peanut roasting (light = 53 ± 1 , medium = 48.5 ± 1 , dark = 43 ± 1 , PATTEE *et al.*, 1991) and peanut paste (ideal value between 58-59, McDANIEL *et al.*, 2012) have demonstrated that this easily accessible and low-cost analysis can be a valuable standardization tool for the candy industry. It can be a parameter for homogenization for peanut roasted portions, when associated with the current control analysis.

The differences in color perceived by the instrumental color analysis can be explained by the processing and operation mode of the ingredients, the peanut roasting in the case, which can generate color alterations in the product by the Maillard reaction (CASTRO *et al.*, 2011), changing the light patterns of the product.

Regarding the sensory traits, none of the participants reported diabetes or peanut allergy, and the data show that the most common frequency of consumption is once a month, comprising 40% of the evaluators, followed by once

a week (25%). The consumption by women is more commonly once a month (26.67%), and an equal proportion of men consume once a month and once a week (13.33%).

Table 4 presents the results of the sensory analysis of the four paçoca brands and their respective evaluated attributes. Peanut shell remnants with a dark brown color could also be observed occasionally in the samples, generating a more heterogeneous appearance.

Table 4 - Result of the sum of the attribute scores and global acceptance for the paçoca brands.

Atributes	Brands			
	A	B	C	D
Color	83 c	149 b	138 b	230 a
Brightness	181 a	160 a	110 b	149 a
Peanut aroma	150 ab	174 a	160 a	116 b
Sweet aroma	140 bc	178 a	161 ab	121 c
Sweet taste	143 a	156 a	168 a	133 a
Peanut taste	148 ab	131 b	149 ab	172 a
Salty taste	131 a	160 a	159 a	150 a
Homogeneous texture	108 c	133 bc	157 b	201 a

Values followed by different letters on the line differ statistically by the Friedman test ($p \leq 0.05$); Minimum difference for 60 evaluators for four paçoca brands = 37; *Values followed by different letters in the line differ statistically by the Tukey's test ($p \leq 0.05$)

Source: Own Authorship (2020)

The sensory analysis of color revealed that brand D had the darkest and most reddish color, whereas instrumental color assessment demonstrated that brand A had the brightest and most yellowish color.

Brands A, B and C were brought together in the most intense class of peanut aroma. However, brand A also did not differ significantly from D brand, which was classified as with less intense peanut aroma. Additionally, regarding the attribute "sweet aroma", B and C brands presented the greatest intensities, while D brand had the lowest sum for this attribute. As observed for the other attributes, the peanut aroma is mainly established by the commercial variety and number of peanuts used in the manufacture of the candy, and their complex volatile compounds are fundamental for the differences in this characteristic (LYKOMITROS *et al.*, 2016; ZIEGLER *et al.*, 2017).

Sweet taste is directly proportional to the amount and type of sugar that is used in the recipe. By the sensory analysis, it was not possible to detect significant

differences among the brands regarding sweet taste. The proximate composition of the paçoca brands (Table 2) indicated differences in the total carbohydrates that may not be noticeable to the human palate.

In candies, the addition of small amounts of salt is commonly performed as a way to enhance the flavor of the mixture. For the attribute “salty taste”, no significant differences were observed among the brands. The labeling data (Table 2) show close values for sodium content among the brands, a difference which is probably imperceptible to the human taste.

The sensory analysis for the homogeneous texture indicated brands A and D as the most and the least homogeneous, respectively. For this attribute, the difference in the size of the peanut grains is the most striking characteristic.

For the results of the global preference ranking of the paçoca brands, there was no significant difference between brands A, B and C, except brand D that belongs to a different statistical class even still presenting similarities with B and C brands. This brand presented divergences from the others in several attributes, such as the darkest coloration, the most striking peanut and sweet aromas, the least peanut taste, and despite the most heterogeneous appearance, its texture presented the greatest homogeneity.

Then, in addition to its physicochemical attributes, such as the highest fiber content and the lowest sodium content, this may justify the observed differences in global preference. In terms of the preference of the paçoca brands for the package and product price, brands A, C and D presented the greatest sums. Nevertheless, brand C did not show any significant differences from brand B, which showed the least preference, probably because it is less known than the other brands, highlighting the influence of the brand in the choice of products by the consumer. When only the commercial brands of each sample were presented, preference was significantly affected.

CONCLUSIONS

In light of the results, all paçoca brands were equally well-accepted. The essential characteristics that increase the preference for different brands of paçoca are greater, lighter and yellowish color, greater brightness and non-

homogeneous texture. To the best of our knowledge, this is the first report of human, instrumental and microbiological-based integrated analysis for the characterization of the popular Brazilian peanut-based paçoca candy. Moreover, the results are relevant to the scientific field of human nutrition since the influence of packaging and price in the choice preference between different commercial paçoca brands were reported.

Avaliação microbiológica, físico-química e sensorial de diferentes marcas de doce de amendoim comercial “paçoca”

RESUMO

A paçoca é um doce à base de amendoim, típico da cultura brasileira. Está associado a algumas tradições religiosas que ocorrem sazonalmente e o consumo ocorre durante todo o ano. Neste estudo, foram avaliadas quatro marcas comerciais de paçoca quanto aos aspectos microbiológicos, composição centesimal, cor instrumental, características sensoriais e rotulagem. Nos testes microbiológicos, não foi identificada contaminação relevante, e a caracterização centesimal mostrou baixa variabilidade entre as marcas. A análise sensorial mostrou uma aceitação relevante de todas as marcas e a análise instrumental de cor indicou diferentes aspectos que podem ser considerados no controle de qualidade do doce, como a cor e o aspecto amarelado, que podem variar de acordo com o processo de torrefação do amendoim. Verificou-se que vários atributos da paçoca são responsáveis por sua aceitação e popularidade na cultura brasileira.

PALAVRAS-CHAVE: rotulagem, atributos sensoriais, aceitação, doce tradicional brasileiro.

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Correspondência:

Marta Regina Verruma-Bernardi

Rodovia Anhanguera, km 174, Araras, São Paulo, Brasil. CEP: 13600-970

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