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Use of silver film from coffee in the production of crunchy flakes

Aproveitamento de película prateada do café na produção de flocos crocantes

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Abstract

Brazil is the largest coffee producer in the world and the second largest consumer of this beverage, portraying the great economic importance of this culture for the country. Like any agro-industrial process, the processing of the coffee fruit generates a large amount of waste. One of these residues is obtained in the roasting stage, being called endocarp or silver film that, until the present moment, is used in the manufacture of animal feed and as a substrate for plant cultivation. The objective of this study was to use silver film as a raw material for producing food: crunchy flakes. The silver film was supplied by a coffee processing company in Chapecó/SC. Initially, flour with the silvery film was produced later used to prepare crunchy flakes. Microbiological analyses of the final product were carried out and the results, compared with the legislation, were in accordance with the required legal standards. The same happened with the physicochemical analyses. Sensory analysis of the crunchy flakes was also carried out in relation to the acceptance of the attributes: color, aroma, flavor, texture, and overall impression using a 9-point structured hedonic scale ranging from extremely liked to extremely disliked, as well as purchase intention. The acceptability test revealed the acceptance potential of the tested product.

Keywords: silver film; coffee; crunchy flakes.

Resumo

O Brasil é o maior produtor de café do mundo e o segundo maior consumidor desta bebida, retratando a grande importância econômica desta cultura para o país. Como todo processo agroindustrial, o beneficiamento do fruto do café gera uma grande quantidade de resíduos. Um destes subprodutos é obtido na etapa de torrefação, sendo denominado endocarpo ou película prateada que, até o presente momento, é utilizada na fabricação de ração animal e como substrato para cultivo de plantas. O objetivo deste estudo foi utilizar a película prateada como matéria-prima para produção de um alimento: flocos crocantes. A película prateada foi fornecida por uma empresa processadora de café do município de Chapecó/SC. Inicialmente, foi produzida uma farinha com a película prateada que, após, foi utilizada na elaboração de flocos crocantes. Foram realizadas análises microbiológicas do produto final e os resultados, quando comparados com a legislação de um grupo similar, estavam de acordo com os padrões legais exigidos. O mesmo aconteceu com as análises físico-químicas. Também foi realizada a análise sensorial dos flocos crocantes, utilizando escala hedônica, bem como intensão de compra. O teste de aceitabilidade revelou o potencial de aceitação do produto testado, com um índice de aceitabilidade de 85,17% em todos os aspectos analisados.

Palavras-chave: película prateada; café; flocos crocantes.

1. NTRODUCTION

Agro-industrial waste generated in significant quantities by companies has received much attention and raised many discussions in recent years about the availability of this waste, its reuse, and application for other purposes (MIRÓN-MÉRIDA et al., 2019). A prominent product is the coffee bean, a product traded worldwide. Brazil is the world's largest coffee producer, with the most significant production located in southern Minas Gerais State, which accounts for 24% of national production, and coffee is integrated into agribusiness (ALVES, LINDNER, 2020). It is estimated that the commercialization of raw beans generates over 50% of byproducts, which cause environmental damage when not properly disposed of. This high generation of waste is associated with the various processing stages, such as collection, pulping, drying, roasting, classification, and milling of the grains (BASÍLIO, 2018).

The roasting process can be described as the passage of the coffee bean through controlled heating, which triggers a series of exothermic reactions that result in the formation of coffee flavor and aroma (LIMA et al., 2014).

The silver film, also called endocarp or parchment, is a byproduct generated as a result of the expansion of the coffee bean during the roasting process. This byproduct is used as a soil fertilizer or animal feed supplement (BASÍLIO, 2018). The composition of the silver film presents characteristics that favor its application in foods as an alternative natural and sustainable ingredient. It is a low moisture content raw material (varying from 5 to 7%) and, on a dry basis, contains 16–19% protein, 1.6–3.3% lipids, and 7% minerals. However, the factor that draws the most attention in this raw material is the high fiber content: about 50% of its composition; this high content of dietary fiber is divided into 15% soluble and 85% insoluble (BASÍLIO, 2018). This byproduct has already been applied in products such as cake flour and gum films with antifungal action (BASÍLIO, 2018; MIRÓN-MÉRIDA et al., 2019).

Given this, this study used the silver film – a byproduct of coffee production – as a raw material for producing a food: crunchy flakes.

2. MATERIALS AND METHODS

2.1 Raw material processing and product elaboration

The silver film was supplied by a coffee roasting company in Chapecó, western Santa Catarina State. Initially, the production of flour was performed. For this, the coffee film was submitted to a drying process in a conventional electric oven at 130 ºC for 15 min. Afterward, the silver film underwent grinding, transforming the raw material into flour. To standardize the granulometry. The silver film flour was sieved with 30- and 60-mesh sieves.

2.2 Preparation of the flakes

To produce crunchy flakes, several formulations were prepared where the dry ingredients were mixed with the wet ones until a homogeneous mass was obtained. The formulations were tested and adjusted until reaching the final formulation (Table 1). The dry and wet ingredients were mixed until the dough was homogeneous.

Then, the dough was shaped until it reached a thickness of about 0.5 cm, cut, and placed on aluminum baking trays, and baked in a conventional electric oven at 220 ºC for 20 min. Afterward, the crushing and selection of the crunchy flakes were performed.

Table 1 - Ingredients and percentages used for the preparation of the formulation.

INGREDIENTS	PERCENTAGE (%)
Rice flour	29.07%
Water	19.38%
Maize flour	14.53%
Sugar	11.63%
Coffee husk flour	7.75%
Chocolate powder	7.75%
Vegetable oil	5.81%
Salt	0.97%
Polydextrose	0.97%
Potassium sorbate	0.97%
Citric acid	0.48%
Anti-humectant	0.48%
Coffee essence	0.19%
Antioxidant (tocopherol)	0.01%

Source: The authors (2022)

Figure 1 - Flowchart of the formulation development process

Source: The authors (2022)

2.3 Characterization of the silver film and the final product

The silver film and the final product (crunchy flakes) were characterized by their physical, chemical, and microbiological characteristics in assays performed in triplicate. The final product was also sensorially evaluated.

2.3.1 Physicochemical analysis

The silver film and the final product were characterized for their contents of soluble solids, pH, titratable acidity, protein, fat, carbohydrates, ash, and moisture in analyses performed according to the methodology Instituto Adolfo Lutz (2008). In addition, fiber analysis was performed for the silver film according to AOAC method 993.19 and AOAC 991.42, 21 of 2019. The experiments were performed in the didactic laboratories of the SENAI Chapecó-SC College and the laboratories of the Food Institute of Senai Chapecó.

The total soluble solids (TSS) were determined by direct reading of the sample in a bench refractometer (model HI 96801 Refractometer) by placing a drop of the solution on the prism and taking a direct reading with temperature correction (Adolfo Lutz Institute, 2008). The potentiometric method determined the pH, where the apparatus was calibrated with pH 4.0 and 7.0 buffer solutions according to the method described by Instituto Adolfo Lutz (2008). The results were expressed in pH units.

The moisture content was determined by drying the samples in an oven at 105°C to constant weight, according to the methodology described by the Adolfo Lutz Institute (2008).

The ash content of the sample was based on determining the weight loss when burned at temperatures between 550 and 570 °C. The weight loss gives the organic matter content of the food, and the difference between the sample's original weight and the organic matter's weight gives the amount of ash present in the product.

The lipid content was determined according to the Soxlet method, which uses petroleum ether as extracting solvent. After extraction, the remaining solvent volume is evaporated in an oven at 105 °C, left in a desiccator, and weighed. The result is expressed as percentages or grams of lipids per 100 grams of sample (Instituto Adolfo Lutz, 2008).

The protein determination was performed according to the Kjeldahl method, which is based on the transformation of the nitrogen in the sample into ammonium sulfate through digestion with sulfuric acid p.a. and subsequent distillation with the release of ammonia, which is fixed in an acid solution and titrated. The results can be expressed as protides by multiplying the percentage of total nitrogen by a specific factor. Titratable acidity (TA) was determined by the titrimetric method, which is based on the neutralization of H + ions with a standardized 0.1 N sodium hydroxide (NaOH) solution using the phenolphthalein indicator until its equivalence point (Instituto Adolfo Lutz, 2008).

Fiber determination was performed through a digestion process that simulates the human digestive tract. Then the soluble and insoluble parts are precipitated by adding 78% ethanol and filtered using diatomaceous earth as a filtering agent in a sintered bottom crucible and determined gravimetrically. The carbohydrate content was calculated by the difference between the sum of the percentages of moisture, protein, fat, and ash and subtracted by 100.

2.3.2 Microbiological Analysis

Microbiological analyses were performed according to Normative Instruction No. 60 of December 23, 2019, for food group: 19 - cereals, flour, pasta, and bakery products. The following assays were performed: presumptive count of *Bacillus cereus* by the ISO 7932:2004 method; detection of *Salmonella* spp. by the AFNOR BIO 12/16-09/05 method, and total count of *Escherichia coli* by the AOAC OMA 991.14 21st ed 2019 method.

For the *Salmonella* spp. analysis, 25 g of the sample was weighed and diluted in 225mL of BPW, then incubated at 37 ± 1 °C for 16–22 h, and then run on VIDAS equipment. It can take up to 5 days to ensure the absence of *Salmonella* spp. in a sample, and confirmation is done with a biochemical series if the sample shows the presence of *Salmonella* spp.

On the other hand, the analysis of Bacillus cereus presumptive count has the results around 3 to 4 days, performed through the standard plate count method, in which 25 g of the sample is homogenized in 225 mL of peptone water with consequent serial dilutions. The number of colony-forming units per gram (CFU/g) was determined by inoculation on MYP agar medium, and the plates were aerobically incubated at 30 ± 1 °C for 18–48 h.

The analysis of *Escherichia coli* was performed by Petri film. This economical and reliable method requires less preparation time, providing agility and precision in the results, and not requiring the preparation of culture media for this analysis. Incubation was performed at 37 °C for 48 h; quantitative results were expressed in CFU/g. All analyses were performed by the Senai Chapecó Food Technology Institute.

2.3.3 Sensory analysis

The acceptance test was conducted in the Sensory Analysis laboratory of the Faculdade SENAI Chapecó. The acceptance test with a 9-point structured hedonic scale, ranging from I liked it very much to I disliked it very much, indicates the degree of acceptability for the attributes of appearance, aroma, flavor, texture, and overall impression.

The test was applied to 50 untrained tasters of both sexes over 18 years of age. The sample was served in 50 mL plastic cups, and the tests were conducted in individual sensory booths with white light. Each tester received a sample containing creamy hot chocolate and whipped cream added with crunchy flakes on the surface. Tasters were instructed that the test was about the crunchy flakes from the coffee's silver film flour.

3. RESULTS AND DISCUSSION

The characterization of this raw material was necessary to know the characteristics of this byproduct, considering that its applicability in the food industry is still unclear due to the scarcity of studies on its applications.

The daily production of silver film, considered a residue from the coffee bean roasting process, is small in the company supplying this study, ranging from 2 to 3 kg daily. Currently, in this company, this residue is destined for animal feed and for composting.

The development of food from the silver film of coffee aims, among other things, to promote inclusive and sustainable industrialization and foster innovation, in line with goal 9 of the Sustainable Development Goals. Improving the technological capabilities of industrial sectors and encouraging innovation contribute to developing reliable, sustainable, and resilient quality infrastructure. In other words, by developing the crunchy flakes, the silver film is no longer a waste product but an industrial application.

3.1 Characterization of the raw material

The results obtained in this study were evaluated and compared with values reported in the literature. The physicochemical characterization of the coffee silver film is presented in Table 2.

Table 2 - Physicochemical characterization of the silver film

ANALYSIS	RESULT
Protein (%)	1.23 ± 0.012
Fat (%)	4.44 ± 0.35
Ash (%)	6.17 ± 0.007
pH	4.45 ± 0.07
Moisture content (%)	14.54 ± 2.0
Acidity (%)	5.54 ± 0.71
Fiber (%)	55.43
Carbohydrates (%)	73.62

*The results are represented by the mean and standard deviation.

Source: The authors (2022)

Few studies related to this product were found. The protein content determined in the present study was 1.23%. In the study by Basilio (2018), the coffee silver film protein had 16.39% and 11.91% in the work of Sánchez and Anzola (2014).

Ash determination allows us to verify the addition of inorganic materials to the food. However, this residue does not always represent all the inorganic substance present in the sample because some salts can suffer reduction or volatilization during heating. The amount of ash found in this study was relatively similar to the values found in the literature. In this work, we obtained 6.17% ash for the silver film; Sánchez and Ansola (2014) reported values ranging from 5.59 to 7.00% ash; thus, we note that our findings corroborate those described in the literature.

When analyzing the sample fat where several coffee varieties were mixed, a value of 4.44% was found for silver film; nonetheless, Sanchez and Anzola (2014) and Basilio, (2018) found values of 2.11 and 6.43%, respectively.

Moisture significantly influences the growth of microorganisms. One of the characteristics of powdered foods marketed as a source of fiber is moisture content below 9%. Basilio (2018) described that the moisture content of silver film was 7.3%, while Sanchez and Anzola (2014) found 6.16%. In this study, the content found was 14.54%. These differences may be associated with the form of storage of the film and the time after its production, meaning if the sample is collected and analyzed soon after the coffee roasting, the moisture content should be lower. Because of the moisture found in the sample, for the production of flour, the silver film went through a previous drying stage precisely to reduce the moisture content and facilitate processing.

The pH prevents spoilage by inhibiting bacterial growth. Studies have proven that foods with low pH help digestion and provide good use of nutrients and vitamins, in addition to preserving food (SÁNCHEZ; ANZOLA V., 2014). The pH result obtained for the silver film was 4.45, which is compatible with pH results found in products of this characteristic (AGNOLETTI, 2015).

The silver film showed a fiber content of 55.43%, close to data surveyed by other researchers. According to Basilio (2018) and Sanchez and Anzola (2014), who presented fiber values of 69.35 and 68.35%, respectively, stated that this product can assist food industries in improving the digestive process and help control cholesterol and blood sugar levels.

Another relevant aspect is that carbohydrates represent the main component of the silver film. When comparing the results of this study, which is 73.62%, with the literature of Sánchez and Anzola (2014) and Basilio (2018) (72.87 and 68.69%, respectively), it can be said that the results are similar and consistent with those found in this study.

Crucial points to consider when making the foods are the taste and smell of the silver film. The smell is quite strong and can be described as smoky, and the strong flavor is bitter and not very reminiscent of the coffee flavor. These characteristics can hinder the application of this raw material in food and beverage products.

3.2 Flour elaboration and application in the formulations

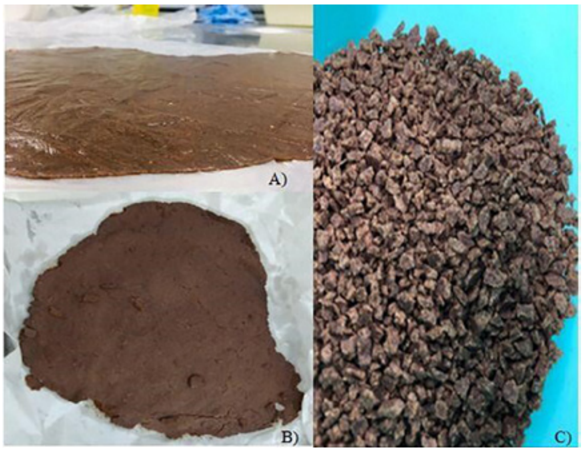
To produce the product, we initially proceeded with producing the silver-film flour. This presented adequate granulometry when passed through a 30- and 60-mesh sieve (Figure 2).

Figure 2 - Flour obtained by drying, grinding, and sieving the silver film

Source: The authors (2022)

In the formulation, a series of ingredients listed above were used, and the mixture was mixed until a homogeneous mass was obtained and then rolled by hand. The dough was baked at 220 °C for 20 min in an electric oven. This way, the process was optimized, presenting a low level of difficulty during all the stages of production. This observation is important because several other processes were previously tested without much success. Thus, this simpler process was chosen since there was no need to pre-cook the ingredients or use specific equipment, especially for laminating and finishing the product. In the end, flakes with a good texture, aroma, flavor, and expected crispness were obtained, thus meeting the initial proposal, which was the elaboration of crunchy flakes from the mixture of a set of ingredients (Figure 3).

Figure 3 - steps in the process of making the crunchy flakes: (A) rolled dough for making the flakes, (B) dough after baking, (C) crunchy flakes after the grinding process.



Source: The authors (2022)

The crunchy flakes can add flavor to various food and beverage options, such as ice cream, hot chocolate, and coffee. During the development of the formulation, we found that the percentage of silver film to be used could not be higher than 8% because it leaves a bitter aftertaste and has a strong odor, characteristic of the coffee roasting stage. Therefore, adding the maximum amount of 7.75% of flour in the formulation was necessary to prevent these characteristics from being present in the final product.

3.3 Characterization of the crunchy flake

The product developed was innovative because the film flour used to make the dough has not been applied to food products. This made it difficult to find other studies and compare the results. Table 3 lists the physical-chemical characterization of the final product, called crunchy flakes, which will initially be destined for companies in the business of products such as coffee and ice cream.

Table 3 - Physicochemical characterization of crunchy flakes

ANALYSIS	RESULTS
Protein (%)	6.5 ± 0.036
Fat (%)	12.79 ± 1.02
Ash (%)	3.78 ± 0.35
pH	4.9
Moisture content (%)	4.89 ± 0.07
Acidity (%)	1.0
Carbohydrates (%)	72.04

Source: The authors (2022)

By analyzing the results of Table 3, one can note that the product had considerable fat content and low moisture content where the method used was specific for lipids, not discriminating the fats found in the byproduct.

Food moisture is directly linked to its stability and quality and affects the product's characteristics. The purpose of moisture control is to reduce water activity in foods, influencing the reduction of microbiological and physicochemical changes (SÁNCHEZ; ANZOLA V., 2014). The moisture content of the product was 4.89%, a satisfactory percentage for maintaining the stability of the food. The type of packaging is essential for the product's protection and shelf-life, considering that products with low moisture content, when stored in packages that do not have adequate barrier properties, can absorb moisture and compromise the crispness of the product. In addition, the packaging is an ally to products with high-fat content because it delays the oxidative process (MACEDO et al., 2009). The product prepared had a fat content of 12.79%, showing that it is necessary to study appropriate packaging that will favor the conservation and maintenance of product characteristics.

According to the results, it is possible to suggest the performance of fiber analysis in future studies because the silver film presents a considerable fiber content and will certainly contribute to the fiber content of the final product used. Furthermore, the characterization of the flour obtained from the silver film in this study could be explored in flake production. With these results, the nutritional table of the product could be elaborated.

3.4 Microbiological characterization

The microbiological analyses (Table 4) performed indicated that the product was in accordance with the standards established by Normative Instruction No. 60 of December 23, 2019. In general, microbiological analyses must be performed to evaluate the microbiological quality of food production. The absence of *Salmonella* spp. in the final product attests to satisfactory hygienic-sanitary conditions, and the low count of *Bacillus cereus* and *Escherichia coli* affirms the null possibility of food poisoning.

Table 4 - Microbiological characterization from the crunchy flakes

PARAMETERS	RESULTS	UN TRAB
M01 - Presumptive enumeration of *Bacillus cereus*	$<1.0x10^{+2}$	CFU/g
M26 - Detection of *salmonella spp.*	Absence	in 25 g
M32 - Total *Escherichia coli* count	$<1.0x10^{+1}$	CFU/g

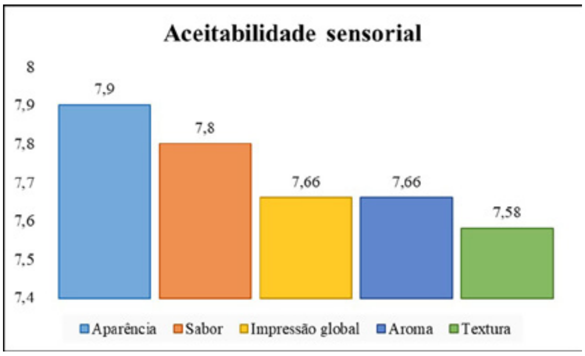
Source: The authors (2022)

3.5 Sensory analysis evaluation of acceptability and purchase intention

Sensory analysis is a method of great importance in evaluating the quality and acceptance of a new food product because no other analysis can replace the sensory receptors that will point out the consumers' preferences.

The acceptability test revealed the acceptance potential of the product tested, in which all the attributes analyzed presented an average above 7, being within the sensorial acceptability standard (Figure 4).

Figure 4 - Judges' evaluation of the sensory attributes of the crunchy flakes



Source: The authors (2022)

The mean scores of the judges who indicated that they intended to buy the product were: 12 judges for "I would certainly buy this product"; 30 judges for "I would probably buy this product"; 7 judges for "I have doubts whether or not I would buy this product"; 1 judge for "I would probably not buy this product." There were 50 judges in total (Figure 5). In order to calculate the product's acceptability index, the expression described in Equation 1 was used:

$$AI\ (\%) = A \times 100/B \qquad \text{(Equation 1)}$$

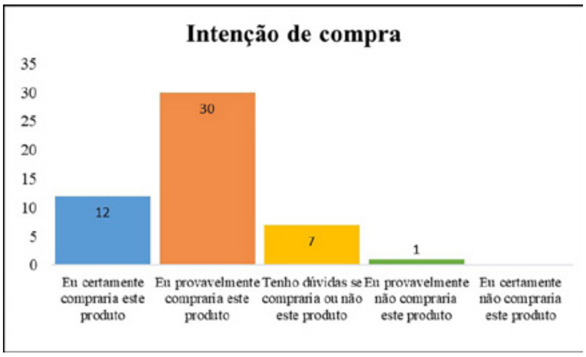
Where:

A = average score obtained for the product,

B = maximum grade given to the product.

Thus, the attributes' acceptability indices were 81.22% for texture, 85.11% for overall impression, 86.66% for flavor, 85.11% for aroma, and 87.77% for appearance. Thus, a product with high market acceptance was obtained, with high percentages concerning the attributes evaluated.

Figure 5 - Column plot indicating the judges' willingness to purchase the crunchy flakes product



Source: The authors (2022)

4. CONCLUDING REMARKS

This study showed an alternative use for the silver coffee film, which was previously discarded by the company and did not generate a financial return. The study on the use of the coffee's silver film revealed a market niche that has been little explored, with few studies related to the application in food, but with a wide field of potential applications since its use can extend beyond the crunchy flakes.

The consumption of an innovative product, such as the crunchy flakes developed in this study, is associated with meeting or exceeding the expectations of the differentiated and demanding consumer public. The sensory analyses performed in this study demonstrated this product's high level of acceptance and purchase intention, even though it is a new product to the public's taste.

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