ISSN 2359-6562 (ONLINE) 2359-6562 (CD-ROM)

ELABORATION AND PHYSICAL-CHEMICAL AND SENSORIAL CHARACTERIZATION OF DRIED BANANA FLAVORED WITH SPICES

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ABSTRACT: Brazil is the fifth largest producer of banana. However, there are significant losses due to transportation and its high perishability and. The osmotic dehydration followed by drying can add value to the product, reduce transportation costs, decrease the acidity, and heighten the taste of the original fruit. Therefore, the work aimed to elaborate dried banana using osmotic dehydration followed by drying, flavored with spices, and to evaluate the physical-chemical and sensorial characteristics. The fresh and flavored bananas were submitted to the physical-chemical analysis. The final product also underwent a sensory evaluation. The water content parameter was according to the legislation for dehydrated fruit. The water activity of the treatments decreased compared to the fresh product, favoring the conservation at room temperature. The reducing sugars increased and were entirely accounted for in the dried banana seasoned with clove and cinnamon. Treatments with clove and fennel were accepted for the attributes of appearance, color, and firmness, but did not present sensory characteristics superior to traditional bananas. Only the dried banana flavored with cinnamon-presented acceptability index higher than 70% for the flavor attribute. However, it is worth noting that this refers to the new food with a peculiar taste.

Keywords: Pacovan, flavorization, osmotic dehydration.

ELABORAÇÃO E CARACTERIZAÇÃO FÍSICO-QUÍMICA E SENSORIAL DE BANANA PASSA SABORIZADA COM ESPECIARIAS

RESUMO: O Brasil é o quinto maior produtor de banana, porém as perdas pela alta perecibilidade e transporte são significativas. A desidratação osmótica seguida de secagem, pode agregar valor, reduzir custos com transporte, diminuir a acidez e elevar o sabor da fruta original. Desta forma, o objetivo do trabalho foi elaborar bananas passa por desidratação osmótica seguida de secagem, saborizadas com especiarias e avaliar as características físico-química e sensoriais. A banana *in natura* e as saborizadas foram submetidas a análises físico-químicas. O produto final também passou por avaliação sensorial. A umidade concordou com a legislação para fruta desidratada, já a atividade de água diminuiu do produto *in natura* para os tratamentos, favorecendo a conservação a temperatura ambiente. Já os açúcares redutores se elevaram, sendo totalmente contabilizados na banana passa com cravo-da-índia e canela. Os tratamentos com cravo-da-índia e erva-doce foram aceitos nos atributos de aparência, cor e firmeza, porém não apresentaram características sensoriais superiores a banana passa tradicional. Apenas a saborizada com canela teve índice de aceitabilidade maior do que 70% para o atributo sabor. No entanto, vale salientar que refere-se a alimento novo com sabor peculiar.

Palavras-chave: Pacovan, saborização, desidratação osmótica.

Recebido em 10/07/2019 e aprovado para publicação em 04/05/2021
DOI: http://dx.doi.org/10.17224/EnergAgric.2021v36n1p145-154

1 INTRODUCTION

Annually, 100 billion bananas (*Musa* sp.) are consumed worldwide (FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, 2016), and Brazilians occupy the second position, which is favored by the fact that Brazil was the fifth largest banana producer between 2010 and 2015, which is cultivated in all states (IBGE, 2016). Bananas are prominent due not only to the quantity produced but also because they meet the caloric needs of millions of people (SOORIANATHASUNDARAM; NADU; NARAYANA, 2016). It is cultivated by small, medium, and large producers, constituting a source of income for the production unit, since it has an almost constant production throughout the year, generating a weekly income (FUNDAÇÃO BANCO DO BRASIL, 2010).

It is appreciated almost entirely when fresh, but also as immature in the form of flour or puree (OLIVEIRA et al., 2015) and mature in the form of mass candy (MARTINS et al., 2011), ice cream (BRIETZKE, 2011) among others such as liqueurs and candy.

It stands out for containing sugars, vitamins, phenolic compounds, besides being rich in potassium, calcium, and magnesium. However, its main component is water, which makes up about 70% of the fruit (AURORE; PARFAITB; FAHRASMANE, 2009), and makes it potentially susceptible to deterioration when mature. Thus, the difficulties concerning its perishability, due to rapid maturation and fragility, and inadequate handling by the loading/unloading employees cause the loss indexes to be significant (SEBRAE, 2008).

The industrialization of the banana may represent the use of the surplus of fruit production during the harvest peaks or fruits that do not present ideal or acceptable appearance for fresh consumption, increasing its useful life and adding value to the product, aiding in loss reduction.

The dried banana is a product with good sensory acceptance and used as an ingredient in the formulations of other products (SENA et al., 2015). In addition to these advantages, the production of dried banana is interesting since it is a nutritious food when undergoing only a drying process, and of high added value, which requires low initial investment for production compared to other fruit conservation methods (VIANA et al., 2017). The consumption of dried fruit in Brazil occurs in the form of pieces, flakes or powder for the production of cake, cand, cookie, cereal bar, panettone, and other fillings. Dehydrated fruits are highly demanded processed products due to its easy consumption and cost reduction with transport (SPERS et al., 2008).

Obtaining the dried banana can also occur by first undergoing osmotic dehydration followed by drying. The osmotic dehydration with subsequent drying in a greenhouse improves the sensory quality of the final product since some acids are removed from the fruit during the osmotic bath, resulting in a product that is softer and sweeter than the common dried fruit. The first stage occurs with solid products, which contain high water content in concentrated aqueous solutions (such as sugar solutions), in which three types of flows are involved. First, there is water flow from the food into the solution. Second, the solids from the solution are transferred to the product and, third, the solutes leave the product (organic acids, minerals, vitamins, and others) to the solution, which is quantitatively insignificant compared to the first two flows but must be considered in the final composition of the product (TORREGGIANI, 1993). According to Sousa et al. (2003), the products obtained from osmotic dehydration followed by drying show improvements in their physical-chemical characteristics and have a more significant effect on preventing microbial development for up to 120 days, as well as good sensorial acceptance.

Of all varieties, the Pacovan is a cultivar belonging to the Silver subgroup, is more vigorous, and a little taller than the Common Silver variety. Its fruits are almost 40% larger (which confers higher productivity), with persistent corners even after maturation, and more acidic pulp (BORGES; SOUZA; LEDO, 2012). It is the most productive when processed in the form of dried banana (JESUS et al., 2005).

Furthermore, the use of spices can contribute to the development of differentiated banana products, conferring pleasant aroma

flavor, favoring its natural conservation when considering the innovation in food production (OLIVEIRA et al., 2017). According to Pereira et al. (2005), in addition to spices and seasonings providing several health benefits, they have shown an inhibitory effect on the development of deteriorating and pathogenic food-borne microorganisms.

Thus, the objective of this work was to elaborate dried banana flavored with spices obtained using osmotic dehydration followed by drying, and to evaluate the physical-chemical and sensorial characteristics of the final product.

2 MATERIAL AND METHODS

The research was conducted at the Laboratory of Fruit and Vegetable Processing of the Industrial School Unit of the Federal Institute of Education, Science, and Technology of Rio Grande do Norte (IFRN), Campus Pau dos Ferros-RN, Brazil, using bananas of the Pacovan variety, obtained from the IFRN Agricultural School Unit, Campus Ipanguaçu.

Initially were selected the fruits in the degree of maturation 6 (PROGRAMA BRASILEIRO PARA A MODERNIZAÇÃO DA HORTICULTURA E PRODUÇÃO INTEGRADA DE FRUTAS, 2006). Subsequently, they were manually peeled and, with the aid of a knife, the film that overs the endocarp and points was removed to avoid astringency due to the high concentration of tannins on the surface of the fruit. After this procedure, the following treatments were used:

• Treatment 1- Osmotic dehydration in sucrose solution (40°Brix/4h) at 60°C, with subsequent drying in a forced air circulation oven, at 60°C, for 30hs;
• Treatment 2- Osmotic dehydration in sucrose solution (40°Brix/4h) at 60°C, with the addition of 30 g of macerated clove, and subsequent drying in a forced circulation oven at 60°C for 30 hs;
• Treatment 3- Osmotic dehydration in sucrose solution (40°Brix/4h) at 60°C, with the addition of 30g of powdered cinnamon, and subsequent drying in a forced air circulation oven, at 60°C, for 30hs;
• Treatment 4- Osmotic dehydration in sucrose solution (40°Brix/4h) at 60°C, with the addition of 30g of fennel, and subsequent drying in a forced air circulation oven, at 60°C, for 30hs.

After drying, the dehydrated bananas were packed, stored at room temperature, and sent for analysis.

2.1 Physical-chemical characterization

The fresh banana and the flavored products were subjected in triplicate to the physical-chemical analysis of water content, ash, pH, titratable acidity, reducing sugars, and non-reducing sugars, according to the methodologies 012IV; 018IV; 017IV; 312 IV; 038IV; and 039IV, respectively, obtained from the Instituto Adolfo Lutz (2008). For the water activity was used portable analyzer Novasina, model Labstart at 25°C.

2.2 Sensorial analysis

The sensorial analysis of the products followed the procedures described by Dutcosky (2013). We conducted an acceptance test using a nine-point hedonic scale anchored between 1-strongly disliked; 2- highly disliked; 3- disliked; 4- slightly disliked; 5- indifferent; 6- slightly liked; 7- liked; 8- highly liked; 9- strongly liked. The sensory attributes of appearance, color, aroma, firmness, and flavor were used, counting on the voluntary participation of 60 untrained tasters chosen at random from students and servers of the IFRN-Pau dos Ferros. The sample was served in medium pieces at room temperature in a disposable plastic cup.

To calculate the Acceptability Index (AI) of each preparation, equation 1 were used:

$$AI\ (\%) = \frac{A}{B} \cdot 100 \quad (1)$$

In which: A is the average grade obtained for the product; B is the maximum grade given to the product, considering that, to be accepted regarding its sensory properties, it is necessary to obtain an Acceptance Rate (AI) of at least 70%.

Finally, a test concerning the intent to purchase was conducted, in which the tasters answered the following question: "which of the samples tested, if marketed, would you buy?" The data obtained was analyzed via the Statistica software version 7.0.

3 RESULTS AND DISCUSSION

3.1 Physical-chemical analyses

Table 1 shows the results of the physical-chemical analysis of the dried bananas from the different treatments. It is worth mentioning that the work was based on legislation for dehydrated or dried fruit (BRASIL, 2005).

Table 1. Physical-chemical characterization of the dried bananas obtained in the different treatments.

	Treatments*				
Parameters	**Fresh (N)**	**T1**	**T2**	**T3**	**T4**
Water content (%)	72.63 ± 0.88^{a}	13.65 ± 0.82^{c}	14.73 ± 0.56^{bc}	15.48 ± 0.46^{bc}	16.19 ± 0.78^{b}
A_w	0.91 ± 0.00^{a}	0.43 ± 0.01^{b}	0.47 ± 0.02^{cd}	0.46 ± 0.00^{d}	0.49 ± 0.01^{c}
Ash (%)	1.07 ± 0.14^{d}	2.49 ± 0.19^{ab}	2.55 ± 0.11^{a}	2.06 ± 0.08^{c}	2.16 ± 0.09^{bc}
Titritable acidity (% malic acid)	0.40 ± 0.09^{c}	1.10 ± 0.06^{a}	1.09 ± 0.02^{a}	0.86 ± 0.02^{b}	0.95 ± 0.02^{b}
pH	4.91 ± 0.03^{a}	4.66 ± 0.01^{bc}	4.73 ± 0.08^{c}	4.57 ± 0.06^{b}	4.75 ± 0.04^{c}
Total sugars (%)	17.84 ± 0.78^{c}	35.89 ± 1.07^{b}	45.62 ± 2.41^{a}	50.34 ± 4.59^{a}	42.18 ± 4.15^{ab}
Reducing sugars (%)	9.48 ± 0.34^{d}	23.80 ±1.76^{c}	45.46 ± 2.00^{a}	49.30 ± 2.19^{a}	36.61 ± 1.02^{b}
Non-reducing sugars (%)	7.99 ± 0.69^{b}	12.09 ± 1.53^{a}	ND**	ND**	8.60 ± 1.90^{b}

***** Mean ± standard deviation followed by the same letters, in the same line, do not differ statistically between each other by the Tukey test at 5% of significance; **ND: not detected. T1 – standard sample; T2 – sample flavored with clove; T3 – sample flavored with powdered cinnamon; T4 – sample flavored with fennel.

As expected the fresh banana showed high water (72.63%), which can reach 77.7% for the Pacovan banana (BELIK, 2011). The water contents in fruits are relevant because they affect the yield in the elaboration of concentrated or dehydrated products (JESUS et al., 2004). Regarding the dried bananas, the water r contents ranged from 13.65 to 16.19%.

Overall, among the treatments there was that the insertion of spices did not significantly influence this parameter. Spices are parts of plants that have several volatile components (CARRIJO et al., 2012), which, in some cases, as when comparing treatments T1 and T4 ($p<0.05$), there may have been loss or not in the calculation of water content. Oliveira et al. (2017) observed that the final water content depends on the percentage of spice (cinnamon) added. This range is also within limits established by the legislation for dehydrated fruits, which establishes a maximum of 25% (BRASIL, 1978).

Moreover, it falls within the established range for fruits with intermediate water content favoring storage at room temperature (SOUSA et al., 2003). The water activity (a_w) was higher in the samples with spice compared to the standard sample. The water seems to have established more connections with the components of the spices and remained in the product. However, the osmotic dehydration is more efficient than the results obtained in the study conducted by Batista et al. (2014) who verified an a_w of 0.65 using only the drying

process. Galdino et al. (2016) reiterate that this low range of a_w is directly related to the temperature used and that this could be further decreased with an increase in temperature.

The content of ash was statistically different between the fresh banana and all other treatments. It seems that sugar saturation is more connected than the addition of spices. Silva et al. (2017) detected 1.44% of ash in the dehydrated silver banana, despite the value in fresh bananas is similar to the value found in this research.

Regarding the acidity, was determined that its value increases with processing, because, with the removal of part of the water, the acids present in the fruit tend to concentrate (JESUS et al., 2005), changing from 0.40% in the fresh fruit to 1.10% in T2. A similar result was observed by Batista et al. (2014) who studied the physical-chemical and microbiological stability of organic dried banana, for the Caipira variety, since it presented 1.05% of ash. Consistently, the pH in all treatments decreased with the concentration of organic acids after drying compared with fresh fruit. It is essential that, after processing, the balance between sugars and acids in the final product is maintained. Mota (2005) obtained results ranging from 4.35 for the apple variety to 4.90 for the nanica variety.

Concerning the total sugars, was observed an increase of approximately 59% when compared to the fresh banana, which can be justified by using osmotic dehydration in sucrose solution (40°Brix/4h). According to Oliveira et al. (2016), this higher content of sugars gives the fruit better conservation capacity. From this perspective, there was a variation between 35.89% and 50.34% for T1 (standard sample) and T3 (flavored with cinnamon powder), respectively, with no statistical difference between the flavored dried bananas. However, the addition of spices interfered with the amount of total sugars since T1 (standard sample) presented a lower value (35.89%) when compared to the flavored dried bananas, especially those flavored with cloves and cinnamon powder.

A variation from 23.80% to 49.30% was verified of reducing sugars for the dehydrated bananas, with a statistical difference only between treatments T1 and T4 (flavored with fennel). Regarding fresh fruit, among the varieties studied by Silva et al. (2012), the Pacovan is prominent for the content of reducing sugars. The standard sample increased its percentage with dehydration. This is justified using the osmotic sucrose solution before final drying, and the concentration of sugars due to the loss of water that naturally occurs throughout the process. In treatments T2 and T3, the clove and cinnamon cause water to remain bound in the food matrix (higher water activity) leaving the sugars freer and easier to be fully quantified. However, further studies are needed to confirm such results.

3.2 Sensorial analysis

The results of the sensorial analysis by hedonic scale for the different treatments of spiced dried banana are presented in Table 2.

Table 2. Mean of the acceptance test regarding the sensorial attributes evaluated in the different treatments.

Parameters	Treatments			
	T1	**T2**	**T3**	**T4**
Appearance	7.14 ± 1.50^{a}	6.68 ± 1.95^{a}	5.66 ± 2.07^{b}	6.35 ± 1.83^{ab}
Color	7.24 ± 1.57^{a}	6.63 ± 1.80^{ab}	5.83 ± 2.10^{b}	6.49 ± 1.83^{ab}
Aroma	6.41 ± 1.97^{a}	6.39 ± 2.05^{a}	6.22 ± 1.97^{a}	6.63 ± 1.79^{a}
Firmness	6.46 ± 2.01^{a}	6.53 ± 2.05^{a}	6.39 ± 2.00^{a}	6.44 ± 2.16^{a}
Flavor	6.43 ± 2.11^{ab}	5.63 ± 2.12^{b}	6.59 ± 1.68^{a}	5.71 ± 2.02^{ab}

***** Means followed by the same letters, in the same line, do not differ statistically between each other at 5% of significance. Nine-point hedonic scale: 1= strongly disliked; 2 = highly disliked; 3 = disliked; 4 = slightly disliked; 5 = indifferent; 6 = slightly liked; 7 = liked; 8 = highly liked; 9 = strongly liked.

It is worth noting that the dehydrated fruits are still little known. According to Santos et al. (2016), 27.70% of people consume the dried banana sporadically, and 23.34%

consume per habit, be it weekly (30%) or in special occasions (20%). However, the dried banana was highlighted as the most consumed dehydrated fruit.

Generally, the different treatments did not significantly interfere in the appearance of the dried bananas since the treatments T1, T2, and T4 do not statistically differ from each other and, although treatment T3 differs from them, it does not differ from treatment T4.

The color was directly affected by the cinnamon powder in T3, which differed from the standard treatment and received a score between "slightly dislike" and "indifferent".

Despite the treatments presenting spices with characteristic aromas, the tasters could not distinguish the aroma of the final product. The grades ranged from 6.22 to 6.63, remaining between "slightly liked" and "liked". The same situation was verified regarding firmness. However, distinctly from the aroma, the texture of the dried fruit has a higher correlation with the content of total soluble solids of the osmotic solution and drying temperature, as found by Castro et al. (2018), who found that the treatment with the highest rejection was the dried banana produced under the conditions of 50°Brix/40°C, whether than the treatments with spices. The samples submitted to the more concentrated solutions presented greater firmness compared to those submitted to less concentrated solutions. This fact can be attributed to the resistance offered during chewing because of the total soluble solids present in greater quantity, which probably occupy the intercellular spaces, decreasing the porosity of the dried fruit (MIRANDA et al., 2015).

The flavor attribute presented statistical similarity between all treatments, differing statistically only between treatments T2 (flavored with clove) and T3 (flavored with cinnamon powder). This difference can be explained by the larger contact surface between the powder cinnamon and the banana at the time of osmotic dehydration, allowing a higher concentration of flavor from this spice.

Table 3 shows the acceptability index for the four treatments. According to Dutcosky (2013), for the product to be considered acceptable regarding its sensory properties, it is necessary that the Acceptance Index (AI) is of at least 70%.

Table 3. Acceptability index (%) for the different treatments of flavored dried banana.

Treatments	Parameters (%)				
	Appearance	**Color**	**Aroma**	**Firmness**	**Flavor**
T1	79.33	80.44	71.22	71.78	71.44
T2	74.22	73.67	71.00	72.56	62.56
T3	62.89	64.78	69.11	71.00	73.22
T4	70.56	72.11	73.68	71.56	63.44

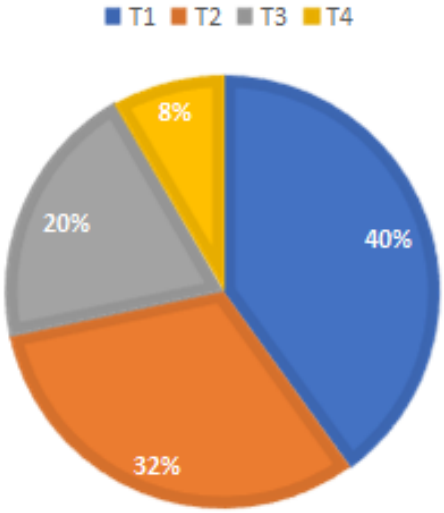
The treatment T3 did not reach the minimum value to be considered acceptable in the attributes of appearance, color, and aroma. Concerning the flavor attribute, the bananas with clove and fennel also failed to achieve an acceptability index above 70%, which is in agreement with the hedonic scale analysis in which the scores ranged from "slightly liked" to "slightly disliked". For this attribute, only the dried banana with cinnamon presented AI of 73.22%. Alternatively, the clove added to treatment T2 can be ground rather than macerated during processing to better incorporate the flavor.

Only the treatment T1 (standard sample) presented AI considered accepted in all attributes, thus constituting the most sensorially accepted sample.

The dried banana in its traditional form received the highest percentage for the possibility of purchase. This was, however, already expected since it is a product available in supermarkets and preferred among dehydrated fruits according to Santos et al. (2016). Treatment with clove presented 32% of purchase intent, followed by cinnamon, with 20% (Figure 1), probably justified by these spices being the most used in culinary preparations, especially cinnamon, which comprise the main

desserts, since banana, cheese, sugar, and cinnamon, are popular in Northeastern Brazil (NUNES; ZEGARRA, 2014). It is worth mentioning that this treatment presented an Acceptance Index more significant than 70% in the flavor item.

Figure 1. Purchase intent for the dried banana obtained in different treatments.



4 CONCLUSIONS

The insertion of spices interferes in the physical-chemical characteristics of the final product, especially the water content, water activity, and reducing sugars, thus improving its conservation. As for the sensorial profile, the treatments with clove and fennel were accepted for the attributes of appearance, color, and firmness, but did not present sensory characteristics superior to traditional bananas. Only the banana with cinnamon obtained an acceptability index higher than 70%. However, it is worth mentioning that it is a new and differentiated product, with a peculiar flavor.

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