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Research Article

Tommy Atkins Mango Foam Mat Drying: Formulation of Functional Foods with Dehydrated Pulp and Sensory Evaluation

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Abstract

Mango is an important tropical fruit in terms of production and consumption, characterized as a fruit of high potential for technological use in the food industry in the formulation of new functional products, presenting an excellent nutritional profile and an important variety of bioactive compounds. Identified of these potentialities, the present study had an investigative focus, testing the formulation of functional foods, from the addition of the dried mango pulp by foam mat drying and performing the sensory analysis of the preparations in order to identify the acceptability of these products formulated with the processed mango compared to products added from fresh mango. Two preparations were formulated (mousse and soft drink) using dehydrated mango as an ingredient. Both formulations were subjected to sensory testing. The panel had 90 tasters and three different analyzes were performed (acceptability, purchase intention and difference test using the triangular method). The results showed a high potential for reconstitution and dispersion of the dried mango pulp in the tested formulations, pointing to its promising use in the food industry. Through sensory analysis, it was possible to identify that the formulations were well accepted by consumers and the results indicate a high potential for commercialization in the food market. Finally, the study showed that the dehydrated mango pulp has excellent technological characteristics to be used in the formulation of new foods.

Keywords: Mango Pulp; Carotenoids; Foam Mat Drying; Sensory Analysis; Functional Foods

Abbreviations

PTFE: Polytetrafluoroethylene Plastic Material; $NA_2S_2O_5$: Sodium Metabisulfite; UFF: Federal Fluminense University; ANOVA: Analysis of Variance

Introduction

Presenting high technological potential, the mango *(Mangifera indica L.)* is the fruit species from the mango tree, characterized as an important tropical fruit in terms of production and consumption

[1]. The fruit has an intense aroma and color, pleasant flavor and excellent nutritional value, being widely appreciated throughout the world, in its different forms of presentation, constituting an important source of bioactive compounds in the human diet, among which stand out phenolic compounds (mangiferin), carotenoid pigments (mainly β-carotene) and vitamin C. It is also worth noting that the fruit has a very short shelf life due to its high moisture content, which makes its handling and distribution difficult post-harvest [2,3].

As it is a seasonal fruit and widely accepted in the fruit market, the industrialization of mango is extremely important in order to reduce losses in excess of crops, promoting better use and designation of the raw material. In this scenario, aiming at making the rational and integral use of fruit feasible, with maximum focus on the preservation of its components, the use of dehydration methods for its conservation becomes interesting, as it leads to the obtaining of stable products and the emergence of new ones products with great potential for incorporation into the food formulation maintaining the original organoleptic characteristics of the fresh fruit [4,5].

The foam mat drying technique is an alternative for the production of by-products derived from mango. In this method, liquids and semi-liquids are transformed into a stable foam, due to the incorporation of air promoted by mechanical agitation in the presence of stabilizers and emulsifying agents, used in order to maintain the integrity of the foam during the drying process, resulting in a processing in the short term when compared to drying solid foods by other methods [4]. The food is dried through exposure to hot air until it reaches a water activity value that prevents microbiological growth and the occurrence of chemical and enzymatic reactions, preserving the content of bioactive compounds in the food [4,5]. At the end of the process, a product with a finely pulverized characteristic is obtained, with a high potential for reconstitution, which can be inserted in the formulation of drinks as juices and as a flavor in sweet preparations [5].

In our previous study, it was shown that the application of this drying method to the Tommy Atkins mango pulp was efficient in increasing its retention of phenolic compounds (including glycosylated xanthone - mangiferin) the total concentration of carotenoids and its antioxidant capacity, pointing out that dehydrated mango presents itself as a promising ingredient in the food market, through the enrichment of preparations with functional appeal, meeting the demands of the current consumer [4,5].

In the world trade in food and foodstuffs, a movement of change is recognized in terms of the level of consumer demand, which brings with it the need to search for increasingly healthier foods, with pleasant sensory characteristics and that show socio-cultural aspects in some way, showing a direct influence on its acceptability. Currently, a variety of formulations prepared with the focus on meeting this recognized demand have been proposed in the food market, which has encouraged the emergence of research that works in the search for new natural and innovative components/ingredients to be included as an alternative source of nutrients, bioactive compounds and an element of sensory focus in production processes.

Objective of the Study

The objective of this work was to formulate functional foods from the addition of mango pulp dehydrated by foam mat drying and to perform sensory analysis of the preparations in order to determine the difference in acceptability in relation to products formulated with fresh pulp, as well as their purchase intention by consumers.

Materials and Methods

Sample

Fruits of the species *Mangifera indica L.,* of the Tommy Atkins variety in maturation stage, were purchased in the food trade in the state of Rio de Janeiro/Brazil. The fruits were selected through subjective visual analysis, considering characteristics such as pulp consistency, fruit shape and skin color [6].

Methodology

Obtaining dehydrated mango pulp

After acquisition, the fruits were benefited through hygiene and manual peeling to separate the core and the pulp. The pulp was beaten in an industrial blender (Metvisa®), refined by sifting and conditioned in bottles of polytetrafluoroethylene plastic material (PTFE), with the addition of sodium metabisulfite ($NA_2S_2O_5$) at a concentration of 200 ppm, and kept under freezing at - 80 ºC until the moment of its use.

The dehydrated mango pulp sample used in this study was obtained through drying in a foam bed, in the condition that stood out best, among 17 different processing conditions tested in our previous study [5], in which it presented the highest concentration of phenolic compounds, carotenoids and anti-pulp capacity of the pulp after the drying process by the foam mat drying technique [4,5].

Formulation of functional foods with dehydrated mango pulp

The chosen processed mango pulp was used as an ingredient in the formulation of functional foods, due to its high content of phenols (mainly mangiferin), antioxidant capacity and carotenoids. The formulated foods were a mango mousse and a reconstituted mango powder for refreshment.

Production of mango mousse

The production flow of the mousse consisted of weighing and initial mixing of homemade yogurt obtained by lactic fermentation of cow's milk for 24 hours, from the inoculation of lactic bacteria *(Streptococcus thermophilus* and *Lactobacillus bulgaricus*) with controlled acidification by cooling, mango pulp dehydrated and refined sugar.

Then the mixture was homogenized in a blender for 3 minutes, followed by the addition of colorless, commercial, flavorless gelatin, hydrated to a gel and a new homogenization cycle for 3 minutes. Table 1 shows the concentrations in g/100g of each of the ingredients present in the formulation.

Composition	Concentration (g/100g)
Homenade Natural Yogurt*	42
Mango Pulp	41
Refined Sugar	7
Filtered Water	8
Colorless Gelatin	1

Table 1: Formulation of mango mousse in 100g.

*Ingredients: Fluid cow's milk + powdered cow's milk + bacteria inoculum.

Mango soft drink production

To obtain mango refreshment, a methodology applied in the practical classes of Dietetic Technique of the Faculty of Nutrition of the Federal Fluminense University (UFF) in Rio de Janeiro/Brazil was used. 17% dehydrated mango pulp, 5% sucrose and 78% filtered drinking water (w/w) were mixed.

Sensory evaluation of mousse and soft drink samples containing dehydrated mango pulp by foam mat drying

The products formulated with the addition of the dried mango pulp were sensorially evaluated to determine the acceptability, purchase intention and differentiation of products formulated with the fresh mango pulp. The analyzes were carried out following the rules of conduct established under Resolution No. 196/96 of the National Health Council for research with human beings, under the approval number CAAE 0188.0258.000-11.

Acceptability test

The acceptance of the formulations was determined by the opinion of 90 tasters using the 9-point mixed hedonic scale test, with the ends anchored in the terms "I liked it a lot" = 9, and "I dislike it a lot" = 1 [7]. The flavor, consistency, aroma and color attributes were evaluated. The recruitment and selection of tasters took place according to their availability, interest in the study and frequency of consumption of mango. Monadically and randomized by a balanced complete block design [8], each taster received a sample containing approximately 30g of each of the formulations prepared in small, disposable white cups, encoded with random three-digit numbers, at room temperature. refrigeration (10ºC). The tasters were offered a glass of water to clean the taste between samples.

Buy intention test

The purchase intention of the formulations was evaluated by a scale with a variation of 7 points, with the ends anchored in the terms "would always buy" = 1 and "would never buy" = 7 [7]. The test result was expressed in frequency.

Sample differentiation test (triangular method)

For the analysis of the sensory difference between the formulations obtained from the insertion of fresh and dehydrated mango pulp, the triangular difference test [9] was used. Comparisons between mousse formulations and refreshments were performed with 60 tasters in each evaluation. Each taster received a sample containing approximately 30g of each of the formulations prepared

in small, disposable white glasses, at refrigerated temperature (10ºC).

Statistical analysis

For treatment and statistical interpretation of the data obtained in the acceptability test, the ANOVA test and the Tukey test were performed, with $p < 0.05$ values considered significant. For the analysis and interpretation of the results obtained in the application of the triangular test, the number of correct answers was counted and the significance table number 2 of the American Society for Testing and Materials [10] was used.

Results and Discussion

Foods formulated with the addition of dehydrated mango pulp

The addition of dehydrated mango pulp in the tested formulations, resulted in samples with a completely homogeneous color spectrum (Figure 1), proving that the powdered mango pulp is capable of completely dispersing in the food matrix, when inserted. Identifying color variation is important for the quality of the final product. The consumer, responsible for the greater or lesser acceptance of the product on the market, judges the quality of the product by color, among other characteristics [11]. A product that shows a significant change in color after certain processing can induce rejection by consumers [12]. The present work allowed the development of these new products as a healthy food option, without affecting the color characteristics of fresh mango pulp. Figure 1 shows the samples of the tested formulations of mousse and mango soft drink.

Figure 1: Sample of tested formulations.
*(A) Mousse sample and (B) soft drink made with mango pulp dehydrated by foam mat drying.

According to Silva., *et al.* [13] the manual elaboration of fruit juices has become an inconvenience to society's fast pace of life. For this reason, the Brazilian consumer has shown a growing interest in consuming products "ready for consumption", which has driven, since the 1990s, the emergence of several commercial brands of industrialized fruit juices in the national market. Therefore, the importance of developing products with a high content of bioactive compounds that can serve as ingredients in other food matrices.

Sensory evaluation

From the tests of sensory analysis used in this study, it was possible to observe the formulations accepted by consumers, if there is an intention to purchase and the sensory difference between the samples. Determining these parameters is important, since the incorporation of bioactive components in food formulations, conveyed through the dehydrated mango pulp by foam mat drying points to a characteristic that is beneficial to the nutritional aspects of the formulation, however, this product needs to be sensorially accepted. by consumers.

Acceptability of formulations

After analysis and statistical interpretation of the data obtained in the acceptability test, from the application of the hedonic scale, a significant difference in acceptance was identified between the samples formulated with the fresh pulp and that produced with the addition of the pulp dehydrated by foam mat drying. Table 2 shows the acceptability averages.

Products	Average*	Arithmetic average**	Bounce rate***
Mousse			
Mousse with powdered mango	6,71a	55,42%	44,57%
Mousse with fresh mango	8,77b	91,95%	8,04%
Refreshment			
Reconstituted powdered mango refreshment	5,24a	44,05%	55,95%
Refreshment with fresh mango pulp	8,94b	92,86%	7,14%

Table 2: Results of the acceptance test for mousse and mango refreshment obtained with the addition of dehydrated and fresh pulp.
*Means followed by different letters differ significantly ($p < 0.05$).
**Grades over 5.
***Grades less than 5.

The figure 2 points out the most appreciated sensory attributes for the acceptance index and the least appreciated for the rejection index, in the mousse and mango refreshment samples, respectively.

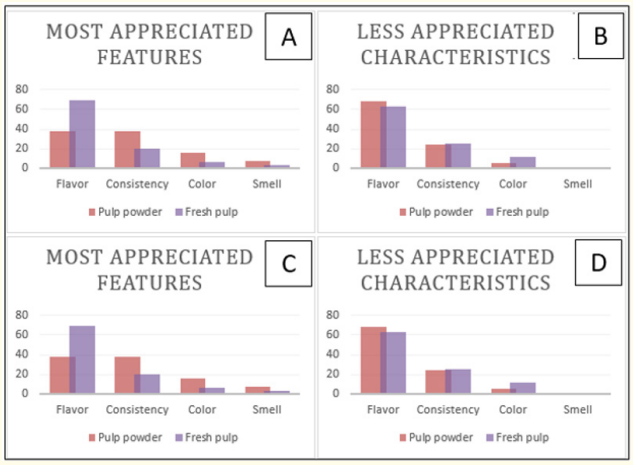

Figure 2: Sensory attributes more appreciated for the acceptance index (A and C) and less appreciated for the rejection index (B and D) in the acceptability test of mousse and mango refreshment, respectively.

* A and B = Mango Mousse/C and D = Mango Refreshment.

It was evidenced in the formulation of the mousse with the fresh mango pulp a higher average acceptance (8.77), while the sample obtained with the dehydrated pulp obtained an average acceptability regarding the scale I liked slightly (6.71). These results indicate positive points for the new formulation with the processed pulp, as it presented a positive average and the acceptance rate was higher than 50%. None of the mousse samples had a rejection rate greater than 50%. For the refreshment samples, the average score for the formulation with fresh pulp was (8.94), referring to the scale I liked a lot. For the drink with the dehydrated mango pulp, 44.05% of the tasters rated the positive hedonic terms, characterizing an average referring to the scale I did not like or disliked.

Thus, it was observed that mousse and fresh mango pulp refreshment, presented greater acceptability, when compared with products with mango pulp dehydrated by foam mat drying. This suggests that the dehydration process under high temperature (80ºC), has an adverse effect on the mango pulp, although visually there is no significant difference between the two pulps in any of the chemical and physicochemical parameters analyzed in the previously guided studies [5].

Probably, the drying temperature should contribute to greater loss of aroma, for example. The taste of the products was the most noticeable characteristic by the tasters. In his study, Cruz [14] found that the process of dehydration by foam mat drying may be associated with changes in the aroma of guava pulp, since the volatile substances in the aroma can be lost by heating in an air current, causing those refreshments with the reconstituted guava pulp would obtain less acceptance for this attribute. A similar trend was reported by Falade and Okocha [15] and Kandasamy., *et al.* [16], respectively, in reconstituted banana powder and papaya juice prepared from powdered pulp obtained by foam mat drying. In the present study, taste was the characteristic most perceived by the tasters, in the products formulated with the reconstituted mango pulp, due to the addition of the stabilizing agent's soy lecithin and carboxymethylcellulose, which can modify the flavor in relation to the product with the mango pulp fresh. Despite the results, the tasters accepted in (55.42% mousse) and (44.05% refreshment), for formulations with the new mango pulp ingredient dehydrated by foam mat drying, being the promising technique for food preparation functional.

The development of new products is essential for the food market, since consumers are demanding and crave constant innovations. One of the fields of food that shows high growth is that of products that bring some health benefit, associating food consumption with healthy lifestyle habits. In general, regardless of the nutritional value of the food, the consumer expects the food to be tasty and meet their expectations.

Difference test by the triangular method

The objective of applying the triangular test was to verify the existence of a significant difference between two samples of the formulations presented, verifying whether changes in specific central and processing ingredients produced sensory changes in the final product. This procedure is characterized as a type of discrimination test, in which the coder is presented with three coded samples, two of which are the same (from the same source of treatment) and one of a supposedly different second treatment, and it is up to the panel to evaluate the samples in the order of offer and identify the

"different" [17]. This method of sensory testing has the advantage of having a better chance of being hit at random (1 in 3) and differentiating the samples offered globally [7].

In order to establish a significant difference with a significance level of 0.1% between the samples, the minimum number of correct answers between the samples of 40 is necessary. Therefore, it was found that there was a sensory difference between the samples of the mango mousse obtained fresh and dehydrated pulp (53 hits) and fresh and dehydrated soft drink (45 hits). The figure 3 shows the results obtained in the difference test using the triangular method.

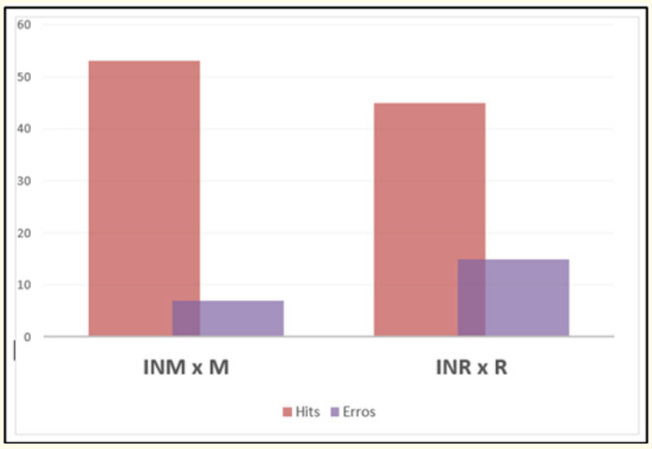

Figure 3: Results of the sensory difference test performed with the tested formulations.

*N = 60 for each comparison; **INM = Fresh mango pulp mousse; ***M = Dehydrated mango pulp mousse; ****INR = Fresh mango pulp refreshment; *****R = Dehydrated mango pulp refreshment.

The dehydration process can be closely linked to processes of modification in the aroma of the mango pulp, since the volatile substances that give this attribute can be lost with the exposure to heating in a draft. The occurrence of a significant difference ($p < 0.05$) between the tested samples is due precisely to these possible changes as a result of changes in the components of the pulp.

The figure 3 shows that the detection of difference between the mousse samples by the tasters, was more pronounced, when compared with the soft drink samples. This fact occurs, due to the fact that some tasters, at the time of sensory analysis, report a better consistency for the formulation of the mousse that contained as an ingredient in the dehydrated mango pulp, which probably occurred due to the addition of foaming agents and stabilizers for initial foam formation by the foam mat process.

Buy intention

The purchase intention of the formulations was evaluated by the tasters and the results were expressed in percentage terms. The results point more than 70% of the tasters to the option "would buy" the mousse formulation with the dehydrated pulp, more frequently in "would buy occasionally" (positive fear), representing 32% for the fresh pulp and 20% for the powdered pulp. Figure 4 shows the percentage data obtained in each term for each formulation of the mango mousse.

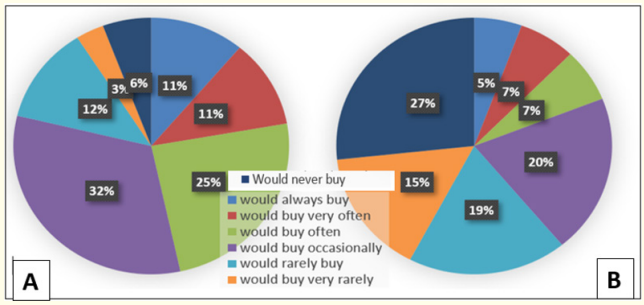

Figure 4: Purchase intent, in percentage, reported by the tasters for the mango mousse with fresh pulp (A) and dehydrated (B).

For mango-based soft drink formulations, the purchase intention evaluated by the tasters resulted in 64% for the option "buy" the new soft drink formulation with dehydrated pulp, more often than "buy occasionally" for the preparation with dehydrated pulp and "would buy often" and "occasionally" for fresh pulp, representing 17% and 24%, respectively. Figure 5 shows the percentage data obtained in each term for each formulation of mango soft drink.

Bastos., *et al.* studied the dehydration of mango pulp of the Tommy Atkins variety by foam mat drying, using *Tween* 60 (0.5%), as a foam stabilizer at 70°C and 85°C drying temperature. In the acceptability tests carried out with the dehydrated and reconstituted mango pulp refreshments, it was evidenced that the dry mango

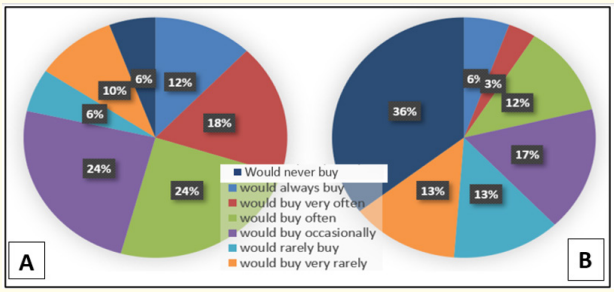

Figure 5: Purchasing intention, in percentage, reported by the tasters for mango refreshment with fresh pulp (A) and dehydrated (B).

drink at 70°C showed better acceptability than the dry mango drink at 85°C. However, both drinks from dehydrated pulp were accepted by the evaluated tasters.

Conclusion

This study showed that the mango pulp dehydrated by the foam mat drying method has favorable technological characteristics to be used as an addition ingredient in the formulation of new food products with functional appeal, since it presents high concentrations of bioactive compounds, such as phenols, including mangiferin, high anti-toxicity and favorable carotenoid composition.

Through sensory analysis, products formulated with dehydrated mango pulp showed good acceptance by the tasters and the results indicated that it is a promising ingredient, with a higher content of bioactive compounds, aiming to contribute as a new alternative for the industrialization of mango pulp fresh.

It should also be noted that the formulations need to be improved, seeking an alternative with greater acceptability by the tasters. There are few studies in the literature showing the applicability of the dried mango pulp by the foam mat drying process.

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Conflict of Interest

The authors report that there are no conflicts of interest in this study. Only the authors are responsible for the content and writing of the manuscript.

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