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Study of the physicochemical characteristics of soursop powder obtained by spray-drying

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Abstract

This study aimed at contributing to the development of new foodstuffs made by soursop pulp powder obtained by spray-drying. Different concentrations of maltodextrin DE 20 (15, 30, and 45%) were added to commercial soursop pulp, which was dehydrated afterwards. The following analyses were carried out: water activity, moisture, pH, soluble solids, acidity, ascorbic acid, hygroscopicity, degree of caking, and rehydration time. The results obtained for the three powder treatments (15, 30 and 45% of maltodextrin) were, respectively: water activity ($0.19^{a}\pm0.00$; $0.20^{a}\pm0.00$; $0.18^{a}\pm0.01$); moisture ($1.17^{c}\pm0.12$; $1.47^{b}\pm0.05$; $1.82^{a}\pm0.06$); pH ($3.75^{a}\pm0.05$; $3.73^{a}\pm0.06$; $3.70^{a}\pm0.03$); soluble solids ($89.67^{a}\pm0.00$; $89.84^{a}\pm0.00$; $90.00^{a}\pm0.06$); acidity ($3.01^{a}\pm0.02$; $1.91^{b}\pm0.03$; $1.24^{c}\pm0.03$); ascorbic acid ($18.90^{a}\pm0.00$; $14.48^{b}\pm0.00$; $11.26^{b}\pm0.78$); hygroscopicity ($5.93^{a}\pm0.40$; $3.82^{b}\pm0.16$; $3.28^{b}\pm0.38$); degree of caking ($78.36^{a}\pm2.86$; $35.38^{b}\pm6.07$; $24.77^{b}4.89$), and rehydration time ($02.03^{a}\pm0.46$; $01.16^{ab}\pm0.50$; $0.59^{b}\pm0.30$). The soursop powders with 30 and 45% of maltodextrin had few significant differences in terms of physicochemical and hygroscopic characteristics, which allow us to consider the percentage of 30% of maltodextrin, in this study, as the best percentage for soursop pulp atomization.

Keywords: maltodextrin; drying; *Annona muricata.*

1 Introduction

The Northeast region of Brazil is distinguished because of its great diversity of fruit species with great commercial value, among which is soursop. This species is an abundant and nutritive fruit, and, currently, it has been considered a medicinal plant (Mata et al., 2005). In Brazil, the largest cultivation areas are located in the State of Bahia, where there are 1,300 hectares of crops and a productivity of 15 tons per year. This region is responsible for 85% of the entire Brazilian soursop production; out of which, 90% accounts for family farm farms (Secretaria de Agricultura do Estado da Bahia, 2012). These fruits have a fragrant sweet-sour white pulp and many dark seeds. There is growing demand for soursop fruit, whose sensorial qualities allow its use for fresh consumption or for processing into food products. Soursop tree also has properties used in homeopathic medicine and home culinary (Batista et al., 2003). In the food processing industry, soursop pulp is used to produce concentrated juice, frozen pulp, nectar, jam, ice cream, alcoholic beverages, diuretic drinks and antiscorbutic syrup (Secretaria de Agricultura do Estado da Bahia, 2012).

The evaluation of the fruit composition evidenced the presence of sugars, tannins, pectins, and vitamins A (β-caroten), C and vitamin B-complex (Ferelli & Nepomuceno, 2005). It is estimated that 100 g of the pulp contains 62 kcal, 15.8 g of carbohydrates, 0.8 g de proteins, 0.2 g of lipids, and Ca (40 mg), Fe (0.2 mg), P (19 mg), Mg (23 mg), Zn (0.1 mg), Mn (0.08 mg), Cu (0.04 mg), K (250 mg), and Na (4 mg) (Núcleo de Estudos e Pesquisas em Alimentação, 2011; Kelmer, 2012).

Food and Agriculture Organization (FAO) data show that the global commercialization of fruit-derived products has grown significantly in the past fifteen years, and a reduction in consumption of fresh fruit in association with an increase in consumption of ready-to-drink fruit-based beverages has been observed (Zulueta et al., 2007).

Freezing is the most commonly used pulp conservation method, but it is often involves inadequate control and poor raw-material handling and processing practices. The freezing process is usually carried out using conventional freezers, which make it very slow and lead to the production of big ice crystals that can harm products' inner structures, especially their texture (Teixeira et al., 2006).

Considering the current trend of nutritious fast food, juice dehydration for use in instantaneous beverages has become an interesting alternative to artificial juices available in the market (Oliveira et al., 2007).

According to Mata et al. (2005), in a study on the soursoup powder obtained by the freeze-drying (lyophilization) process, the soursoup powder had a water content of 2.1 g/ 100g, pH of 4.7, total soluble solids of 39.4 °Brix, total titulable acidity of 0.85 g/ 100g, total soluble solids and total acidity ratio of 46.3, and vitamin C content of 32.6 mg/ 100g.

This study aimed at using spray-drying process to obtain soursop pulp powder to elaborate new powdered foodstuffs.

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2 Materials and methods

Frozen soursop pulps were purchased from local retailers in Fortaleza, Ceará. These frozen pulps, packed in polyethylene bags – appropriate for commercialization (100g) were placed in expanded polystyrene boxes, transported to the Laboratory of Quality Control and Drying of DETAL/UFC, and stored in a freezer at a temperature of –18°C.

After defrosting, pulp solutions were formulated with fresh soursoup pulp and 15, 30, and 45% of maltodextrin DE 20. After complete dissolution and homogenization, the formulated solutions were spray-dried in a spray-dryer (MSD 1.0 - Labmaq do Brasil LTDA) using a 1.2mm pneumatic nozzle and the following parameters: pulp feed rate (0.5 L/h); hot air flow (3.5 L/h); air inlet temperature (120°C); air outlet temperauture (80°C); and air flow rate (30L/min).

The soursop pulp powder was placed in laminated vacuum packages and vacuum packed at room temperature (25 ± 2°C) and relative humidity of 55% ± 2%. At firstly, the physicochemical characterization of fresh soursop pulp was performed and, after drying the formulated pulps, the powder obtained was also characterized. All analytical determinations were carried out in triplicate.

Physicochemical analyses for pH, total soluble solid (°Brix), titratable acidity (TA), and moisture were performed using the Instituto Adolfo Lutz (2005) method. As for ascorbic acid content, the method described by Stroheckert & Henning (1967) was used, and the water activity in soursop pulp powder was determined using a water activity 4TEV meter, (Brazil), at 25°C, according to the manufacturer's indications.

A Konica Minolta CR-410 colorimeter (Japan) was used to determine the color parameters using the CIE L*a*b* system, which included the variables L*, Chroma (C*) and Hue angle (H_0*); where L* corresponds to lightness and it varies from 0 (black) to 100 (white), C* is related to color intensity, and H_0* varies from 0 to 360°.

Hygroscopicity was determined following the method A 14a, described by GEA Niro Research Laboratory (2003), which consists of exposing the powder to a relative air humidity (RH) of 79.5% that will be adsorbed by the powder sample until reaching a constant increase in weight (Table 1).

The degree of caking was determined following the method A 15a, described by GEA Niro Research Laboratory (2003), which consists of exposing the powder to absorb moisture from the air with 79.5% of relative humidity until it reaches equilibrium. Afterwards, the powder was dried and sieved under standard conditions (500 mm sieve mesh); the powder remaining in the sieve was expressed as degree of caking (Table 2).

Rehydration analysis followed the method described by Goula & Adamapoulos (2010), which consisted of adding 2.0g of the material to 50mL of distilled water; the mixture was agitated in a 100mL beaker. The time required for the material to be rehydrated was recorded.

The physicochemical data were submitted to analysis of variance (ANOVA) using the Statistica version 7.0 software (StatSoft, 2007), and the F-test was used to determine statistical significance at 95% confidence interval.

3 Results and discussion

The results of physiochemical characterization of the fresh soursoup pulp and the soursoup powder are shown in Table 3. As can be seen, soursop pulp had a water activity value compatible to aW values previously reported for fruit pulp (a_w > 0.95). Fruits with water activity values higher than 0.98 are more susceptible to deterioration by bacteria, fungi and yeast (Abreu et al., 2003).

The results obtained showed that, from a physicochemical point of view, the soursop pulp values of total soluble solids (T.S.S.), pH, total acidity (T.A.) and ascorbic acid are within the standards determined by law, which are - T.S.S: at least 9.00 °Brix; pH: 3.57; total acidity: 0.6 g/100g of citric acid; and ascorbic acid: 10.00 mg/100g (Brasil, 2000).

As for the color parameters, an L* value of 71.00 ± 0.22 was found indicating light pulp. As for the H_0* values (which correspond to the following plant surface colors: 0°/red; 90°/yellow; 180° /green; and 270°/blue), the value obtained for the soursop pulp was H_0* = 96.31 ± 1.84, indicating yellow color, which is within the limits established by law that establishes that soursop pulp color should vary from white to ivory.

The water atomization process reduced water activity in fresh soursop pulp by more than 76%. Water activity is one of the most important properties of food processing, conservation, and storage. It is a measure of the energy status of the water and of the availability of water and, as a consequence, its availability to act as a solvent and participate in chemical, biochemical, and microbiological transformations.

The powders obtained by the atomization of soursop pulp with different concentrations of maltodextrin did not differ statistically in terms of water activity. The water activity average values obtained, according to Ferreira Neto et al. (2005), can

Table 1. Values used to determine hygroscopicity, according to GEA Niro Research Laboratory (2003).

Hygroscopicity	Percentage (5)
Non-hygroscopic	<10%
Slightly hygroscopic	10.1 – 15%
Hygroscopic	15.1 – 20%
Very hygroscopic	20.1 – 25%
Extremely hygroscopic	>25%

Table 2. Values used to determine degree of caking, according to GEA Niro Research Laboratory (2003).

Caking degree	Percentage %)
Non-caking powder	<10%
Slightly caking powder	10.1 – 20%
Caking powder	20.1 – 50%
Very caking powder	>50%
Extremely caking powder	100%

inhibit the development of bacteria (0.9), yeast, and fungi (0.6-0.8), favoring the product's storage period.

The percentage of maltodextrin influenced the product final moisture, showing a linear relationship with the increase in percentage of maltodextrin since the soursop pulp powder with 45% of maltodextrin had the highest moisture values. Although the powders differ statistically, the average moisture values are much lower than the maximum value established by law, which is 25% of moisture for dry or dehydrated fruit products. Mata et al. (2005), investigating soursoup powder obtained by the freeze-drying (lyophilization) process, found moisture values of 2.1%, which is above the result found in the present study. Therefore, this difference can be due to the different dehydration processes used.

The powder pH values were slightly higher than those found for fresh pulps due to the concentration of the product, as a consequence of dehydration. The average pH values of the powder did not differ statistically, with values ranging between 3.7 and 3.75, which indicate that the products are, from a food technology point of view, within a safe range in terms of microbial development. According to Azeredo (2012), foods with pH lower than 4.0 are classified as very acid foods.

Titratable acidity decreased as the percentage of maltodextrin increased, showing an inverse relation with the increase in percentage of this drying co-operant. The fact that one gram of powder with 15% of maltodextrin contains more pulp than one gram of powder with 45% of maltodextrin may be related to this difference in acidity since soursop pulp powder with 15% of maltodextrin was more acid than the other powders.

The same behavior of TA was observed in the analysis of ascorbic acid, even though there was no significant difference between the powders with 30 and 45%. In the present study, low concentration of ascorbic acid in the atomized soursop pulp was observed, and it is is not within the recommended daily intake (45 mg/day) as suggested by ANVISA (Brasil, 2005).

The color of the powder was also influenced by the percentage of maltodextrin, and there was a significant difference between the powders obtained. The increase in L* and in H_0*, in parallel with a decrease in C*, for the powder with 15% and 45%, suggest that the powders became lighter with increasing maltodextrin concentration.

In terms of hygroscopicity, according to the GEA Niro Research Laboratory (2003) table, the soursop powders obtained are classified as non-hygroscopic (<10%). The values were much lower than those found by Angel et al. (2009), in a study on spray-drying of passion fruit juice using maltodextrin and lactose as drying adjuvants, who found higroscopicity values between 17 and 35%. Soursop pulp powder with 15% of maltodextrin showed significant statistic differences when compared to the values of the other powders, but it maintained the same classification (Table 4). The lowest percentage of maltodextrin influenced soursop powder hygroscopicity, showing an inverse relation: the higher the percentage of maltodextrin, the lower the values of hygroscopicity. This occurred because maltodextrin has low hygroscopicity, which can affect the existing affinity between water and other compounds in the product.

According to Borges (1988), the evaluation of dried food higroscopicity is very important, especially in fruits, because of the influence on packaging (such as agglomeration, degree of caking, and loss of fluidity). It is also intimately associated to the chemical, physical, and microbiological stability of these products.

Caking formation can justify this fact since it was higher in soursop powder with 15% of maltodextrin, which was classified as very caking powder (>50%). The other powders were classified as caking powder (20-50%). According to

Table 3. Physicochemical characterization of fresh soursop pulp and soursoup powder with different maltodextrin concentrations.

ANALYSES	FRESH PULP	Pulp Powder With maltodextrin 15%	Pulp Powder With maltodextrin 30%	Pulp Powder With maltodextrin 45%
Water activity	0.99^{a}±0.01	00.19^{b}±0.00	00.20^{b}±0.00	00.18^{b}±0.01
Moisture^{+}	6.68^{a}±0.16	00.01^{c}±0.12	00.02^{b}±0.05	00.02^{b}±0.06
pH	3.57^{a}±0.02	03.75^{a}±0.05	03.73^{a}±0.06	03.70^{a}±0.03
T.S.S. (° Brix)$^{+}$	9.20^{d}±0.06	89.68^{c}±0.00	89.86^{b}±0.00	90.02^{a}±0.06
T.A. (% citric acid)$^{+}$	01.04^{d}±0.04	03.01^{a}±0.02	01.91^{b}±0.03	01.24^{c}±0.03
Ascorbic Acid (mg/100g)$^{+}$	15.53^{b}±0.00	18.90^{a}±0.00	14.48^{c}±0.00	11.26^{d}±2.78
L*	71.00^{d}±0.22	93.82^{c}±0.13	94.39^{b}±0.09	94.77^{a}±0.07
Chroma	14.94^{a}±0.28	09.58^{b}±0.06	08.90^{c}±0.04	06.86^{d}±0.04
Hue	96.31^{a}±1.84	88.58^{d}±0.06	91.27^{c}±0.04	92.14^{b}±0.01

Means followed by the same letter in the same row do not differ significantly, according to the F-test at 95% of confidence; $^{+}$ = Results expressed on dry basis (d.b).

Table 4. Hygroscopicity, degree of caking, and rehydration time of atomized soursop pulp.

Analyses	Samples		
	15%	30%	45%
Hygroscopicity (%)	5.93a±0.40	3.82b±0.16	3.28b±0.38
Caking Degree (%)	78.36a±2.86	35.38b±6.07	24.77b±4.89
Rehydration (s)	02.03a±0.46	01.16ab±0.50	0.59b±0.30

Means followed by the same letter in the same row do not differ significantly, according to the F-test at 95% of confidence.

Downton et al. (1982), caking occurs through water absorption in powdered dried foods with high sugar concentration. This progressive absorption, according to Endo et al. (2007), facilitates the mobility of the sugar molecules in the amorphous state, inducting their crystallization, releasing water and forming liquid bridges between the sugar particles. This mechanism forms clusters that, with time, lose water, forming solids bridges and rigid clusters. With regard to the rehydration analysis, the same behavior exhibited for hygroscopicity was observed, in which the lowest percentage of maltodextrin took a longer time to complete the rehydration of the powder.

4 Conclusion

The atomization process significantly reduced the water content of fresh pulp, which resulted in a product with moisture and water activity stability in terms of product preservation.

Soursop powders with 30 and 45% of maltodextrin showed few significant differences in the physicochemical and hygroscopic analyses, which allows us to suggest that, in the present study, the 30% of maltodextrin is the best percentage for soursop pulp atomization.

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