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Obtaining candied fruit of calabash (*Lagenaria siceraria)*

Obtenção de fruta cristalizada de caxi (Lagenaria siceraria)

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Edited by:
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Section:
This article was submitted to Food technology, a section of the Journal of Bioenergy and Food Science

ID JBFS2462018

DOI 10.18067/jbfs.v5i4.246

Reviews process:
Prot. 2462018R01 (Brazil)
Prot. 2462018R02 (Brazil)

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Competing interests
The authors have declared that no competing interests exist.

Funding:
The authors have no support or funding to report.

Received: September 03, 2018

Accepted: November 17, 2018

Published: December 01, 2018

Citation:
Cortez-Vega, W. R., Pinedo, R. A., Bertuci, M. L., Pizato, S. P., Maldonado, C. A. B., & Arévalo-Pinedo, A. (2018). Obtaining candied fruit of calabash (*Lagenaria siceraria*). *Journal of Bioenergy and Food Science*, *5*(4), 119-130. doi: 10.18067/jbfs.v5i4.246

ABSTRACT

Calabash is considered a non-traditional herb, for not being normally consumed. Osmotic dehydration is an alternative to add value to this vegetable. The objective of this study was to develop candied fruit of calabash (*Lagenaria siceraria)* and evaluate their physical, chemical and sensory characteristics. The calabash was sanitized, peeled, cut into cubes and bleached. For the osmotic process of calabash pieces, sucrose was dissolved in water and treatments were prepared namely: T1 - Sucrose concentration at 10%; T2 - Sucrose concentration at 20%; T3 - Sucrose concentration at 40% and T4 - Sucrose concentration at 60%. The calabash cubes remained in their respective concentrations for a period of 10 days until complete saturation. After the crystallization the cubes were washed in running water and dried in an oven at a temperature of 60°C for 6 hours. The physical, chemical, microbiological and sensory analyzes were performed. There was no significant difference between the treatments for pH values. The treatment T4 showed higher value of ascorbic acid (2.06) at the end of the treatment days. Moisture was greater in treatment T1, while T4 presented the lowest moisture content. T4 showed higher soluble solids content. The values found for molds and yeasts were within the legislation. The treatments T3 and T4 showed the highest acceptance rate for all the evaluated attributes. The *in natura* calabash transformation for its candied form added value to this product.

Keywords: Adding value. Crystallization. Saturation. Sensory analysis.

RESUMO

O caxi é considerado uma erva não tradicional, por não ser normalmente consumido. A desidratação osmótica é uma alternativa para agregar valor a esse vegetal. O objetivo deste trabalho foi desenvolver frutas cristalizadas de caxi (*Lagenaria siceraria*) e avaliar suas características físicas, químicas e sensoriais. O caxi foi sanitizado, descascado, cortado em cubos e branqueado. Para o processo osmótico dos pedaços de caxi, a sacarose foi dissolvida em água e os tratamentos foram preparados, obtendo: T1 - Concentração de sacarose a 10%; T2 - Concentração de sacarose a 20%; T3 - Concentração de sacarose a 40% e T4 - Concentração de sacarose a 60%. Os cubos de caxi permaneceram em suas respectivas concentrações por um período de 10 dias até a completa saturação. Após a cristalização os cubos foram lavados em água corrente e secos em estufa a uma temperatura de 60°C por 6 horas. As análises físicas, químicas, microbiológicas e sensoriais foram realizadas. Não houve diferença significativa entre os tratamentos para valores de pH. O tratamento T4 apresentou maior valor de ácido ascórbico (2,06) no final dos dias de tratamento. A umidade foi maior no tratamento T1, enquanto o T4 apresentou o menor teor de umidade. T4 apresentou maior teor de sólidos solúveis. Os valores encontrados para bolores e leveduras estavam dentro da legislação. Os tratamentos T3 e T4 apresentaram a maior taxa de aceitação para todos os atributos avaliados. A transformação do caxi *in natura* para sua forma cristalizada agregou valor a este produto.

Palavras-chave: Agregando valor. Cristalização. Saturação. Análise sensorial.

INTRODUCTION

Calabash (*Lagenaria siceraria*) also called bottle gourd, is considered a non-traditional herb, for not being normally consumed. It is a Cucurbitaceae a native of Africa, where it was already used as herbs at the time of the Americas discovery (Teppner, 2004). Distributed over the whole world, there is an enormous variability of shape and size of fruits. The calabash fruits when green have a tender and pubescent peel and pulp with high moisture content. When the fruit is ripe the peel becomes thick and lignified, turning impervious and with dry and fine pulp (Whitaker & Davis, 1962; Bisognin & Storck, 2000).

For culinary purposes, fruits and young branches are consumed as food. In Asia, the pulp of fruit developed from a particular variety of calabash is cut into strips and subjected to drying for use in typical dishes. Today, it is recommended that its consumption be in the cooked form and should be preferably given to the non-bitter types. (Robinson & Decker-Walters, 1962).

Brazil is a major producer of plant origin products. However, it is estimated that between the harvest and the arrival to the consumer's table, quantitative or qualitative losses occur around half of the production, i.e., 30 - 40 % of the fruit and vegetables never reach the consumer (Queji & Pessoa, 2011). The industrialization and application of techniques that keep their nutritional components and organoleptic properties and also increase the conservation time would be one of the alternatives to reduce these losses, enabling the rational profit (Andrade, Metri, Barros Neto & Guerra, 2003).

Dehydration is one of the oldest conservation methods, being that the osmotic dehydration leads to minimal changes of color, texture and nutritional value (Andrade, Barros Neto, Nóbrega, Azoubel & Guerra, 2007). The osmotic dehydration (OD), or alternatively called impregnation or saturation, is an important operation to transform the perishable fruits in new products with added value and greater useful life (Torreggioani & Bertolo, 2001; Perez, Oliveira, Andrade & Moreira Filho, 2013). This process is the water removal where the fruits are subjected to immersion in hypertonic solution that has a high osmotic pressure. In plant cells, the cell wall, which contains numerous relatively large interstices, is not as the main barrier, being permeable to water and small solutes. The direction of the force of water removal happens between the food and the solution, where the permeable membrane allows the diffusion happens from the food to the solution, and from this for the food (Egea & Lobato, 2014).

The objective of this study was to develop candied fruit of calabash (*Lagenaria siceraria*) and evaluate their physical, chemical and sensory characteristics.

MATERIAL AND METHODS

a) Raw material

Calabash (*Lagenaria siceraria*) was purchased at a fair free of the city of Dourados, MS - Brazil. The fruits that had smooth peel and firm texture were chosen, being the same transported to the Laboratory of Food Processing at the Federal University of Grande Dourados - UFGD.

b) Obtaining the cubes

First the fruits were washed in tap water, and then sanitized with chlorine organic (2g L^{-1}) for a period of 15 min After, rinsed with water and dried. Then the fruits were pulped manually for the peel withdrawal, with the aid of a stainless steel knife previously sanitized with chlorine and organic water at a concentration of 2g L^{-1}. After the peel withdrawal the same were cut in half where the seeds and fibrous central part were removed.

Slicing was immediately performed, whose cuts were in the form of cubes of 1cm^3, and brought to the heat treatment (bleaching) for 3 min with boiling water. After this time the thermal shock was given with iced water to avoid loss of components and maintain firm the pulp texture into cubes.

c) Osmotic process

The candied calabash process was obtained by immersing the cubes in water with different sucrose concentrations, using the slow and conventional sugary method. According to Lombard et al. (2008), the fruit cut into slices considerably reduces the drying time, also increasing the contact surface between the syrup and fruit. A completely randomized design was used, obtaining 4 treatments: T1 - Sucrose at 10%; T2 – Sucrose at 20%; T3 - Sucrose at 40% and T4 - Sucrose at 60%. After the junction of sucrose and water, in proportions, these solutions were brought to boiling, until reaching the complete sucrose dissolution. Then the syrup was cooled (30°C) and soon after the calabash cubes were submerged. The cubes remained in constant submersion in overnight. After this period in each treatment the concentration of sugar in each treatment was incremented by 5%. This is repeated for a period of 10 days. This addition of 5% of sugar to each treatment was performed every two days (day 2, 4, 6, 8 and 10) to obtain the complete saturation and the crystallization of the cubes. To find out if the medium was saturated during this period soluble solids measurements were performed, using bench refractometer.

During the osmosis process drops of green dye were added, for use in food, to give greater attractiveness to the judges during the sensory analysis, however, this dye does not interfere with the product organoleptic characteristics, only with the visual aspect of the same.

d) Drying

The calabash pieces, after the crystallization were removed from their syrups, then washed in flowing water quickly with the help of a sieve. All the liquid was left to drain for a period of 2 min. Then, the pieces were packed into the dryer trays (NG Científica, Mod. S/R) with air circulation and temperature of 60°C, for a period of 6 hours. After drying they were stored in polypropylene bags of 20x10x5 cm and sealed to the physical-chemical, microbiological and sensory analyses.

e) Physical-chemical analysis

For comparison purposes, physical-chemical analyses were performed in the *in natura* fruits and in calabash pieces already candied. The parameters analyzed were:

pH, acidity, moisture and water activity. Whereas only in the candied fruits analyzes were performed for the soluble solids determination. All analyzes were performed in triplicate.

For the pH analysis a suspension of 20g of sample was prepared in 100 mL of distilled water, being used a potentiometer (Marconi PA 200). The analysis was performed according to the method described by AOAC (2000).

The total titratable acidity was determined and calculated as the volume in mL of NaOH 0.1 mol L^{-1}, required to titrate 10 mL of the diluted sample and homogenized in 100 mL of water. The results were expressed in ascorbic acid percentage (AOAC, 2000).

For the moisture content determination of the calabash fruits *in natura* and pieces of candied calabash, aluminum capsules were used previously dried in an oven. Then 5 g of sample were weighed, and these were dried in an oven for approximately 5 hours at a temperature of 105°C. After this period the capsules were weighed, and repeated the same process until they reached constant weight (Instituto Adolfo Lutz, 2008).

Water activity was determined by means of the hygrometer (Aqualab BrasEq brand), first the equipment was stabilized, after it was placed in the capsule shredded pieces of candied calabash and then this capsule was placed in the equipment compartment until stabilization, whose data were obtained by direct readings in the appliance.

f) Microbiological analysis

Yeasts and molds were determined in candied calabash samples (4 treatments), in accordance with the parameters required by the legislation (BRASIL, 2001) according to the methodology described by Silva et al. (2007).

g) Sensory analysis

The sensory tests were carried out at the Sensory Analysis Laboratory of the Engineering School (FAEN/UFGD). The samples regarding the 4 treatments were coded with three-digit numbers at random and presented to the tasters. The sensory evaluation was done by means of global acceptance test, using a structured hedonic scale of 9 points, where 1 represents the minimum (I really disliked it) and 9 the maximum score (I liked it very much), being that the attributes evaluated were of the same color, taste, odor and overall appearance. The test was applied using 100 untrained tasters.

The samples were evaluated in individual booths under white fluorescent light and at temperature environment (±25°C). The tasters were instructed to rinse the mouth with water between the tasting of each sample in order to eliminate any residual or sweet taste and that might interfere with the evaluation.

After the judges have proved the samples, the index of acceptability (IA) was calculated, which is a percentage value that has as objective to obtain the consumers' product acceptance. For the product to be considered as well accepted, the minimum value of IA should be 70% (Dutcosky, 2013).

For this calculation the following mathematical expression was adopted:

$$IA = (\text{Mean obteined from the sample})/(\text{Maximum scale note used })\text{x}100$$

Eq. (1)

h) Statistical analysis

The results were statistically analyzed using the analysis of variance (ANOVA) using the software Statistica® 7.0 (StatSoft, Inc., Tulsa USA). The averages were determined using Tukey's test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Table 1 presents the values of physico-chemical analyzes of *in natura* calabash fruits (*Lagenaria siceraria*).

Table 1. Values obtained for physico-chemical analyzes of *in natura* calabash fruits (*Lagenaria siceraria*)

Parameters	Product *in natura*
pH	5.93±0.03
Ascorbic acid (mg/100g)	18.38±0.35
Moisture (%)	94.32±1.31
Water activity (Aw)	0.997±0.08

As it can be seen in Table 1, a pH value of 5.93 was found. This value is close to the values found for fresh vegetables of the same family (Cucurbitaceaea) of calabash, as well as in pumpkin (6.11) and of the chayote (6.57) (Alves, Vilas Boas, Vilas Boas & Souza, 2010). Whereas Tamer, Incedayi, Yönel, Yonak and Çopur (2010) found a pH of 5.8 to minimally processed pumpkin, value which is closer to the one found in this study for calabash.

The ascorbic acid or vitamin C is a powerful antioxidant naturally present in many foods (Egea & Lobato, 2014). The concentration of ascorbic acid found for *in natura* calabash was 18.38 mg/100g of sample.

The vegetables mostly have high water content. The moisture found for *in natura* calabash was 94.32±1.13%. Whereas Alves, Vilas Boas, Vilas Boas and Souza (2010) found a value of moisture for the chayote of 95.39%, value higher than that found in the present study for calabash.

Water activity found for the calabash fruit was 0.997. This value is high and is related to the fact that the moisture for this fruit was also high. The water activity measurement is important, because it is this water that is available to the microbial growth and enzyme reactions. The raw chayote's water activity found in work developed by Oliveira, Srur & Vacari (2002) is similar to that found in this study for calabash.

Table 2 presents the values of physico-chemical analyzes in the fruits of candied calabash (*Lagenaria siceraria*) with different glucose concentrations.

Table 2. Values obtained for physical-chemical analysis of the fruits of candied calabash (*Lagenaria siceraria*) with different glucose concentrations at the end of 10 days of sugary process

Parameters	Treatments			
	T1	T2	T3	T4
pH	3.96±1.98^{a}	3.93±0.05^{a}	4.0±0.04^{a}	4.07±0.04^{a}
Ascorbic acid (mg/100g)	0.39±0.19^{b}	0.39±0.19^{b}	0.65±0.23^{b}	2.06±0.05^{a}
Moisture (%)	22.16±0.66^{a}	16.26±1.15^{d}	19.90±0.43^{b}	18.78±0.45^{c}
Water activity (Aw)	0.723±0.00^{b}	0.670±0.00^{c}	0.650±0.00^{d}	0.758±0.01^{a}

Equal letters in the same line did not differ significantly among themselves, by Tukey test ($P<0.05$). Where: T1 - Sucrose at 10%; T2 - Sucrose at 20%; T3 - Sucrose at 40% and T4 - Sucrose at 60%.

The pH values found in four treatments evaluated in this study for candied calabash cubes did not differ statistically among themselves at the end of the period of 10 days of osmotic dehydration.

These values are important, because the product can be stored for a long period of time, at this level of pH. Oliveira, Srur and Vacari (2002), working with candied chayote found values close to the present study (4.31). The lowest values of pH of the candied calabash cubes found in four treatments in relation to *in natura* sample is due to the fact that the sugar in aqueous solution has a pH slightly acidic. In a study carried out by Ribeiro and Sabaa-Srur (1999), where the authors saturated mangoes with sugar, it was observed similar trend of increase in acidity and with this decrease in pH to the saturated mangoes, this reduction in pH was attributed to a possible process of self fermentation of the medium where the fruits were.

A higher content of ascorbic acid was found in this study in the calabash cubes, when they were in contact with the sucrose solution at 60% (2.06±0.05) during the 10 days of treatment being only this treatment (T4) that differed significantly from the other treatments.

When the value of ascorbic acid was compared of the cubes of the fruit *in natura* with the candied fruit, it was verified that there was a well marked loss of this compound. The steps for cutting and agitation expose the vitamin C to oxygen, with consequent oxidation (Fernandes et al., 2007). In addition, the osmotic process which uses the temperature increase is responsible for the thermal degradation of this vitamin (Martins, Cunha & Silva, 2008). The losses of vitamin C decrease with the realization of the osmotic process as pre-treatment for convective drying, as has already been proven to oranges (Mendes, Freitas, Scaglioni, Schmidt & Furlong, 2013) and apple (Egea, Borsato, Silva & Yamashita, 2012). Martins, Cunha and Silva (2008), studying dried cashew nuts produced by osmotic dehydration, found high losses of vitamin C (86 to 95 %) when compared to the content of vitamin C of the *in natura* pseudo fruit. The present study also found the values of loss of vitamin C among the fruits *in natura* and 95% of the candied. The authors aforementioned justify that the stability reduction in this case happened because the fruits processing consisted of cutting half, immersion in aqueous solution and drying at temperatures of up to 65°C. In the present study the drying was performed in a similar temperature (60°C) which also contributed to the loss of this vitamin.

The moisture value found at the end of the process for the pieces of candied calabash was 22.16% to T1, 16.26% to T2, 19.10% to T3 and 18.78% to T4. The highest amount of moisture found for T1 is due to the fact that this treatment presented a lower concentration of sucrose (10%) in relation to the other treatments. Being that the greater the quantity of sucrose in the more pronounced the osmosis process, losing thus the fruit a larger moisture percentage.

All treatments performed to dehydrated calabash presented % moisture content below 25%. According to Oliveira, Srur and Vacari (2002) and Morita et al. (2005), a moisture content below 25% ensures good products conservation at ambient temperature, in addition making the product have smooth and dry surface, a common characteristic of dehydrated fruits, since they are stored in packages that work with good barrier to the water steam passage.

The water activity content (Aw) for osmotically dehydrated calabash cubes were between 0.758 (higher value) and 0.650 (lower value).

Table 3 shows the determination of the soluble solids content for 4 treatments evaluated during the period of 10 days of monitoring of calabash cubes with different sucrose concentrations.

Table 3. Determination of the soluble solids content during the storage period of the calabash cubes (*Lagenaria siceraria*) kept in different sucrose concentrations

Days of Monitoring	Treatments			
	T1	T2	T3	T4
1	$11.0±0.05^{dE}$	$18.0±0.23^{cE}$	$20.5±0.02^{bE}$	$27.5±0.30^{aE}$
3	$23.0±1.23^{dD}$	$38.0±0.64^{cD}$	$41.5±0.05^{bD}$	$42.0±0.12^{aD}$
5	$33.0±0.18^{cC}$	$57.0±0.05^{bC}$	$59.0±1.05^{aC}$	$60.0±0.33^{aC}$
8	$40.0±0.67^{dB}$	$58.0±0.12^{cB}$	$62.0±0.34^{bB}$	$64.0±0.64^{aB}$
10	$53.0±0.95^{dA}$	$60.0±1.12^{cA}$	$63.0±0.34^{bA}$	$66.0±0.20^{aA}$

Means followed by the same uppercase letter, in the columns and lowercase in the line do not differ statistically among themselves by the Tukey test (P>0.05). Where: T1 - Sucrose at 10%; T2 - Sucrose at 20%; T3 - Sucrose at 40% and T4 - Sucrose at 60%.

The measurements for the sucrose control were performed every 2 days for a period of 10 days. It is possible to see in Table 3, that in 10 days the sucrose content differed significantly for the four treatments, being that the treatment T4 showed the highest value (66%). This was already expected because the sucrose concentration at T4 (60%) was higher than that of the other treatments evaluated in this study.

During the dehydration process, some solutes present in the syrup may not migrate effectively to the fruits and vegetables cells, but only penetrate the intracellular spaces and host there, because of the changes in the permeability and selectivity of the structure of the cellular tissue due to maturation, storage conditions and chemical pre-treatment suffered by the product (Egea & Lobato, 2014). This impregnation of the solute in food, somehow, allows the functional products formulation and promotes the nutritional and sensorial preservation, being a differential among the other dehydration processes (Vega-Gálvez et al., 2007).

The increase in the natural fruit solids concentration due to loss of water that occurs by osmotic pressure difference between the fruit and the sugar solution and by sugar absorption by the fruit from the solution used as a means of osmotic drying (Morita et al., 2005). This was verified in the present study, because, as time went by there was an increase in the soluble solids content.

The results of this study to the soluble solids content (Table 3) is in accordance with Andrade, Metri, Barros Neto and Guerra (2003), that when these authors worked with osmotic dehydration of genipap in different sucrose concentrations (30, 50 and 70 %), showed that the highest sucrose concentrations favor the loss of water, promoting, at the same time, higher gain of soluble solids. Valera, Zambrano, Materano and Quintero (2005) also observed an increase in the soluble solids content as time went by when he worked with the osmotic dehydration in mango.

In Table 4 are presented the results of the microbiological analyzes for molds and yeasts for the calabash (L*agenaria siceraria*) osmotically dehydrated and crystallized.

Table 4. Analysis of yeasts and molds of calabash (L*agenaria siceraria*) osmotically dehydrated

Treatments	Values
T1	<2.0x10^2 CFU.g^{-1}
T2	<3.5x10^3 CFU.g^{-1}
T3	<3.0x10^2 CFU.g^{-1}
T4	<1.7x 10^2 CFU.g^{-1}

Where: CFU/g - Colony forming unit per gram; T1 - Sucrose at 10%; T2 - Sucrose at 20%; T3 - Sucrose at 40% and T4 - Sucrose at 60%.

Observing the results obtained for molds and yeasts in samples of calabash osmotically dehydrated and candied (Table 4), it is possible to verify that it complies with the microbiological standards described in the dried fruits legislation (BRASIL, 2001), which showed low values of molds and yeasts (<10 CFU.g^{-1}), putting the product out of risk of microbiological contamination, which is in accordance with the legislation that establishes a maximum for molds and yeasts of 5x10^3 CFU g^{-1}. According to Lombard, Oliveira, Fito and Andrés (2008), the osmotic dehydration guarantees the products stability such as for example the calabash, with high quality during its useful life, due to the low water activity contained in the final product and the high sucrose content.

The lowest value for molds and yeasts were found in T4. This may be due to this treatment present a higher sucrose concentration during calabash production osmotically dehydrated and defruited, making the high concentration of sugar a greater barrier to the yeasts and molds emergence. Lima, Figueiredo, Maia, Lima and Sous (2004), working with the drying of melons osmotically dehydrated, found values similar to the present study (defruited calabash) for molds and yeasts.

The acceptability indexes (IA) for color, taste, odor and overall appearance obtained for the calabash samples through sensory analysis are presented in Table 5.

Table 5. Acceptability indexes evaluated for calabash (*Lagenaria siceraria*) osmotically dehydrated and defruited

Sensory attributes (%)	Treatments			
	T1	T2	T3	T4
Color	72.22±0.55[c]	75.76±2.05[b]	78.22±0.40[a]	77.44±1.03[ab]
Flavor	66.77±0.67[d]	73.88±0.72[c]	75.88±0.80[b]	79.25±1.12[a]
Odor	66.11±1.29[d]	69.44±0.18[c]	78.25±1.08[b]	80.33±0.33[a]
Global Appearance	69.05±1.35[d]	73.28±0.89[c]	75.40±0.50[b]	79.77±1.22[a]

Where: T1 - Sucrose at 10%; T2 - Sucrose at 20%; T3 - Sucrose at 40% and T4 - Sucrose at 60%.

So that a product is considered accepted by its sensory properties, it is important that an index of acceptability is obtained of at least 70% (Teixeira, Meinert & Barbeta, 1987; Bastos, Paulo & Chiaradia, 2014). The treatments T3 and T4 were the treatments that showed better acceptance by the judges. Regarding the attribute color, it is possible to see that the treatments T3 and T4 showed no significant difference between themselves, already in the other attributes evaluated there was no significant difference between them, being that the treatment T4 was the one that had better acceptance.

The T2 presented to the odor attribute value less than 70% and the treatment T1 presented values below 70% for the attributes of taste, odor and overall appearance, being considered the one that pleased the tasters the least. This is due to the lowest sugar concentration of this treatment during the osmotic process period.

The acceptance rate found for T4 was above 70% (75%). The acceptance values to dehydrated calabash were lower when compared to a study conducted by Morita et al. (2005), who worked with dehidrated melon, where they obtained an acceptance of 90%.

CONCLUSIONS

The calabash after having passed through the osmotic dehydration process, presented physical and chemical characteristics very similar to other products from the same family. The microbiological parameters for this product were in accordance with standards required by legislation.

The calabash obtained by osmotic dehydration in sucrose concentrations of 40 and 60% (T3 and T4) were the favorites among the tasters for the attributes overall appearance, color, odor and flavor, being that these two treatments were the ones which showed higher sensory acceptance values.

In this study it was found that the candied calabash production is a way to increase value to the product, to be better harnessed and avoid large losses during this vegetable harvest.

AUTHOR CONTRIBUTIONS

Adviser professor of this work and elaborated the scientific article: RPA and WRC-V; Carried out the analyzes of this study and elaborated the scientific article: TDB and SP; Co-Adviser professor of this work and supported the preparation of the article: CAMB; Supported the preparation of the article: AA-P.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

FUNDING

The authors have no support or funding to report.

REFERENCES

Alves, J.A., Vilas Boas, E.V.B., Vilas Boas, B.M. & Souza, E. C. (2010). Maintenance of the quality of fresh-cut products made up of pumpkin, carrot, chayote, and arracacha (*Peruvian carrot*). *Ciência e Tecnologia de Alimentos*, *30*(3), 625-634. http://dx.doi.org/10.1590/S0101-20612010000300009

Andrade, S.A.C., Barros Neto, B., Nóbrega, C.A., Azoubel, P.M. & Guerra, N. B. (2007). Evaluation of water and sucrose diffusion coefficients during osmotic dehydration of jenipapo (*Genipa Americana* L.). *Journal of Food Engineering*, *78*(2), 551-555. http://dx.doi.org/10.1016/j.jfoodeng.2005.10.023

Andrade, S.A., Metri, J.C., Barros Neto, B. & Guerra, N. B. (2003). Osmotic dehydration of jenipapo (*Genipa americana* L.). *Ciência e Tecnologia de Alimentos*, *23*(2), 276-281. http://dx.doi.org/10.1590/S0101-20612003000200029

AOAC. (2000). Association of Official Analytical Chemists. *Official methods of analysis*. 16th ed. Washington, D.C.

Bastos, G.A., Paulo, E.M. & Chiaradia, A.C.N. (2014). Acceptability of potentially probiotic cereal bars. Brazilian *Journal of Food Technology, 17*(2), 113-120. http://dx.doi.org/10.1590/bjft.2014.012

Bisognin, D.A. & Storck, L. (2000). Variance components and heritability estimation for fruit shape in bottlegourd – *Lagenaria siceraria* (Molina) Standl. *Ciência Rural*, *30*(4), 593-597. http://dx.doi.org/10.1590/S0103-84782000000400006

Brasil. (2001). Ministério da Saúde. Resolução RDC nº 12, de 02 de janeiro de 2001. Aprova o Regulamento Técnico sobre padrões microbiológicos para alimentos. Diário Oficial [da] República Federativa do Brasil. Brasília, DF, 10 jan. 2001. Seção 1, p. 46-53.

Dutcosky, S.D. (2013). Análise sensorial de alimentos. 4ed. Curitiba: Champagnat. 531p.

Egea, M.B. & Lobato, L.P. (2014). Fruits and vegetables with osmotic dehydration pretreatment. *Revista Instituto Adolfo Lutz*, *73*(4), 316-324. http://dx.doi.org/10.18241/0073-98552014731621

Egea, M.B., Borsato, D., Silva, R.S.S.F. & Yamashita, F. (2012). Osmo-dehydrated functional product containing fructo-oligosaccharides: physical, chemical and sensorial characteristics. *Brazilian Archives Biology and Technology*, *55*(6), 927-936. http://dx.doi.org/10.1590/S1516-89132012000600017

Fernandes, A.G., Maia, G.A., Souza, P.H.M., Costa, J.M.C., Figueiredo, R.W. & Prado, G.M. (2007). Comparison of vitamin C, total carotenoids, total anthocyanins, and total phenolic compounds in guava tropical juice in different stages of processing and influence of storage. *Alimentos e Nutrição*, *18*(4), 431-438.

Instituto Adolfo Lutz. (2008). Análise sensorial. *In*: Métodos físico químicos para análise de alimentos. São Paulo.

Lima, A.S., Figueiredo, R.W., Maia, G.A., Lima, J.R. & Sous, P.H.M. (2004). Stability evaluation in dehydrated melons obtained by a combination of osmotic dehydration and conventional drying. *Revista Brasileira de Fruticultura*, *26*(1), 107-109. http://dx.doi.org/10.1590/S0100-29452004000100029

Lombard, G.E., Oliveira, J.C., Fito, P. & Andrés, A. (2008). Osmotic dehydration of pineapple as a pretreatment for further drying. *Journal of Food Engineering*, *85*(2), 277–284. https://doi.org/10.1016/j.jfoodeng.2007.07.009

Martins, M.C.P., Cunha, T.L. & Silva, M.R. (2008). Effect of dehydration osmotic conditions on the quality of cashew apple from cerrado. *Ciência e Tecnologia de Alimentos*, *28*(1.0), 158-165. http://dx.doi.org/10.1590/S0101-20612008000500025

Mendes, G.R.L., Freitas, C.H., Scaglioni, P.T., Schmidt, C.G. & Furlong, E.B. (2013). Conditions for osmotic dehydration of oranges and functional properties of the product. *Revista Brasileira de Engenharia Agrícola e Ambiental*, *17*(11), 1210-1216. http://dx.doi.org/10.1590/S1415-43662013001100012

Morita, A.S., De Gois, V.A., Praça, E.P., Tavares, J.C., De Andrade, J.C., Da Costa, F.B., Júnior, A.P.B. & De Sousa, A.H. (2005). Crystallization of melon fruit through slow sugary process. *Ciência Rural*, *35*(3), 705-708. http://dx.doi.org/10.1590/S0103-84782005000300035

Oliveira, L.F., Srur, A.U.O.S. & Vacari, F. (2002). Chayote profit (*Sechium edule*, Swartz) by process of sugar saturation – a dietary alternative. *Revista Universidade Rural – Série Ciências da Vida*, 22(2), 93-98.

Perez, L.G., Oliveira, F.M.N., Andrade, J.S. & Moreira Filho, M. (2013). Kinetic drying of cupuaçu pulp (*Theobroma grandiflorum*) pre-dehydrated by immersion-impregnation. *Revista Ciência Agronômica*, *44*(1), 102-106. http://dx.doi.org/10.1590/S1806-66902013000100013

Queji, M.F.D. & Pessoa, L.S. (2011). Influence of osmotic treatment in production of dehydrated tomato. *Revista Brasileira de Tecnologia Agroindustrial*, *5*(1), 282-292. http://dx.doi.org/10.3895/S1981-36862011000100004

Ribeiro, M.S. & Sabaa-Srur, A.U.O. (1999). Mango (*Mangifera indica L.*) cv. rosa saturation with sugars. *Ciência e Tecnologia de Alimentos*, *19*(1), 118-122. http://dx.doi.org/10.1590/S0101-20611999000100021

Robinson, R.W. & Decker-Walters, D.S. (1962). Cucurbits. Cambridge: University Press-CAB.

Silva, N., Junqueira, V.C.A., Silveira, N.A., Taniwaki, M.H., Santos, R.F.S. & Gomes, R.A.R. (2007). Manual de Métodos de Análise Microbiológica de Alimentos. São Paulo.

Tamer, C.E., Incedayi, B., Yönel, S.P., Yonak, S. & Çopur, O.U. (2010). Evaluation of several quality criteria of low calorie pumpkin dessert. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *38*(1), 76-80. http://dx.doi.org/10.15835/nbha3813557

Teixeira, E., Meinert, E. & Barbeta, P.A. (1987). Análise sensorial dos alimentos. Florianópolis.

Teppner, H. (2004). Notes on Lagenaria and Cucurbita (*Cucurbitaceae*) – review and new contributions. *Phyton*, 44(2), 245-308.

Torreggiani, D. & Bertolo, G. (2001). Osmotic pre-treatments in fruit processing: chemical, physical and structure effects. *Journal of Food Engineering*, *49*(2-3), 247-53. http://dx.doi.org/10.1016/S0260-8774(00)00210-7

Valera, A., Zambrano, J., Materano, W. & Quintero, I. (2005). Efectos de la concentración de soluto y la relación fruta/jarabe sobre la deshidratación osmótica de mango en cilindros. *Agronomía Tropical*, *55*(1), 117-132.

Vega-Gálvez, A., Palacios, M., Boglio, F., Pássaro, C., Jeréz, C. & Lemus-Mondaca, R. (2007). Deshidración osmótica de la papaya chilena (*Vasconcellea pubescens*) e influencia de la temperatura y concentración de la solución sobre la cinética de transferencia de materia. *Ciência e Tecnologia de Alimentos*, *27*(3), 470-477. http://dx.doi.org/10.1590/S0101-20612007000300008

Whitaker T.W. & Davis G.N. (1962). Cucurbits-botany, cultivation and utilization. Leonard Hill, London, United Kingdom. 249 pp.