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RESEARCH PAPER

Production of crystallized fruit from watermelon rind

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Abstract

M. Gontero, A. Brandelli, and C. Zapata Noreña. 2010. Production of crystallized fruit from watermelon rind. Cien. Inv. Agr. 37(2): 55-60. The aim of this work was to produce crystallized fruit from watermelon rind. The following procedure was developed: the outer peel was removed; the material was sliced into 7 mm cubes, blanched for, 0, 5 and 10 minutes, and then treated with 10% sodium chloride solution. This product was treated with solutions of sucrose (30 to 72 °Brix), and dried in a hot air dryer at different temperatures (40, 60 and 80 °C). Products were then analyzed by a sensory panel. The experimental design used was randomized blocks and the results were analyzed by the Tukey's test. The best acceptance of the sensory panel was for the product obtained by 5 minutes blanching followed by drying at 60 °C, whose intensity values for appearance, flavor and gummosis were between 6 and 7.

Key words: osmosis, watermelon, dehydration, agricultural waste.

Introduction

Commercialization of fruits and derivatives are facing a growing demand due to improvements made in transportation systems, distribution, development of new products and processing methods. Fruits from non tropical zones are characterized by a wide edible portion and moderate amounts of residues. On the other hand, the processing of tropical and subtropical fruits like bananas, watermelons and mangos, generates a wide amount of by-products (Askar, 1998; Schieber *et al*., 2001). Therefore, it is necessary the development of efficient, economic, as well as environmentally correct technologies, in order to take advantage of the residues generated by these products through the whole production and commercialization chain.

A high percentage of food is currently lost due to the lack or misuse of conservation technologies and post-harvest storage, as well as damages caused during handling and transportation and rejection of products by the market, because they do not fulfil quality patterns. In order to face this challenge, the process of osmotic dehydration is being used because it is a method allowing increasing the storage life of these products. The principle of conservation consists on reducing the water activity, which allows diminishing the speed of the chemical, biochemical and microbiological reactions responsible of food decay (Berbari *et al*., 1992). Rastogi *et al.* (1997) define osmotic dehydration as a process of partial removal of free water of some food, like fruits and vegetables, when they are immersed in a hypertonic solution.

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In recent years, these products have been appreciated by consumers, because they preserve their nutritive properties and are minimally processed (Torreggiani and Bertolo, 2001). Park *et al.* (2003) mention that this method has advantages in quality (color, flavor, texture) and for diminishing the costs in energy, distribution, packaging and storage.

Among the different products that may be obtained by osmotic processing are crystallized fruits, where there is a simultaneous water elimination and inclusion of sugars (Berbari *et al.*, 1992). Subsequently, the product is subject to hot air drying (Southgate, 1992). Soler *et al.* (1995) classified fruits dehydrated osmotically by sugars like crystallized sugars, when they are not covered by a layer of sugar and glazed crystals, even when they were covered by a layer of an oversaturated sugar solution.

Alvarez *et al.* (1995) studied the effect of blanching and glucose concentration on the speed of air drying at 55°C in strawberries, observing that the coefficients of water diffusion were strongly affected by blanching. Nieto *et al.* (2001) evaluated the previous effect of blanching and osmotic dehydration by glucose, made at atmospheric pressure and vacuum, on an air drying process at 60°C, in mango. They found that the values of water diffusion decreased and, there was a higher addition of glucose and modifications in cell starch and mucilaginous substances as a consequence of blanching. Sacchetti *et al.* (2001) report on sodium chloride that this salt is used due to the possibility of increasing the speed of the process of osmotic dehydration in apples, using sacarose solutions, without affecting their sensorial characteristics.

The objective of this work was the elaboration of crystallized products from watermelon rinds, evaluating the effect of blanching and the temperature of drying air on the sensorial characteristics of the final product.

Materials and methods

The watermelons (*Citrullus vulgaris* Schrad) were purchased in the Central Market of Porto Alegre, Rio Grande do Sul, Brazil. The initial moisture of the watermelon was 95,76%. After being washed and dried, the watermelons were stored at a temperature of 20±2 ºC.

The watermelons were subject to the procedure of selection, wash and rind separation from the edible part and seeds shown in Figure 1. Then, the external green cuticle was eliminated from the rind (around 4 mm). The rind was diced in cubes of approximately 7 mm each side, and blanched in boiling water during 0, 5 or 10 minutes. After that, the samples were introduced in a NaCl solution at 10% during 5 hours. Then, the rind cubes were immersed in a sugar solution of 30 ºBrix, measured with a table refractometer, remaining in that solution during 24 hours. Subsequently, they were placed in a sugar solution of 40 ºBrix, and left to stand for another 24 hours. This procedure was repeated successively (50, 60, 70 °Brix) until the cubes were introduced in a solution of 72 ºBrix.

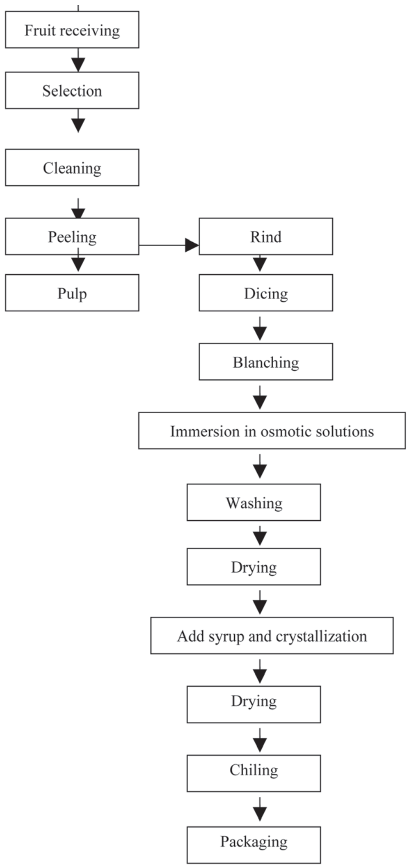

Figure 1. Flow chart for crystallized fruit from watermelon rind.

In order to enable the fruit preservation, the solution of 60 °Brix was maintained at pH 4 (measured with pH-meter), for which citric acid was used.

After the process of sugars impregnation, the fruit syrup was retrieved and washed with distilled water and then drained, to eliminate the excess of solution from the surface. Subsequently, the samples were dried in hot air dryer at temperatures of 40, 60 and 80 ºC, during 4 hours. Then, the surface of those products was smeared with syrup and covered with a layer of crystallized sugar and left in a oven at 60 ºC for an hour. Finally, the cold product was packaged in high density polyethylene bags.

Sensorial analysis

The tests of flavor were made in individual cabins, illuminated with white fluorescent light. The samples were served in white porcelain dishes, coded with random 3-figure-numbers, along with a glass with water at room temperature.

The judges evaluated the samples according to the attributes (descriptive terms), established by the method of discriminating terms list: appearance (samples shine), flavor (associated to the sweet flavor of sacarose), chewiness (how easily the product is ground by the teeth and ready to consume) and gumminess (if the product is attached on the teeth during disintegration).

Eight previously selected evaluators, from 20 to 45 years old, analyzed the intensity perceived in each attribute with the help of a non structured horizontal scale. The evaluation card contained a 9.0 cm scale, between limits of totally like and totally dislike.

Statistical design

The experimental planning for the sensorial analysis was made with a completely randomized block design. The treatments evaluated are shown in Table 1. The Tukey comparison of means test was used in order to verify the existence of significant differences between the treatments (with a level of significance of 0.05). For the statistical analysis, the statistical software, SAS was used, version 9.1.3 (SAS Institute).

Table 1. Treatments applied to the samples.

Treatment	Blanching time (min.)	Drying temperature (ºC)
A	0	40
B	0	80
C	10	40
D	10	80
E	5	60

Results and discussion

The results of the means of the sensorial attributes from each sample, compared by the Tukey's test are in Table 2, with a $p \leq 0.05$.

Some significant differences were observed in this work between the results from the comparison of the treatments as a consequence of the statistical tests ($p \leq 0.05$). In regard to the appearance, the results indicated that the blanched sample during 5 minutes and dried at 60 ºC (E), which presented a higher significant intensity, in regard to the lower intensity of the treatment made with 10 minutes of blanching and drying at 40 ºC (C).

In regard to flavor, the treatments A, B and D were equal to each other, but significantly different ($p \leq 0.05$) from C and E, which were the samples obtaining the highest intensities (blanched during 10 minutes and dried at 40 ºC and blanched of 5 minutes and dried at 60 ºC, respectively), which were not different among them. In regard to the samples resulting with lower score in flavor, these were the treatments A and B, both without blanching.

When the chewiness was evaluated, the tests showing the highest intensity were subject to blanching for 10 minutes and drying at 40 ºC (C), and the sample with 5 minutes of blanching

Table 2. Mean values compared by Tukey's test.

Treatments	Appearance	Flavor	Chewiness	Gumminess
0min/40 °C (A)	3.15 a	2.59 a	3.45 a	3.77 a
0min/80 °C (B)	5.03 b	2.51 a	2.53 ac	3.55 a
10min/40 °C (C)	1.96 c	6.39 b	5.59 b	7.15 b
10min/80 °C (D)	5.60 b	3.14 a	2.16 c	3.3 a
5min/60 °C (E)	6.96 d	6.38 b	4.91 b	6.93 b

Different letters indicate significant differences ($p \leq 0.05$).

and drying at 60 ºC, without differences among them ($p \geq 0.05$). On the contrary, the tests which were less intense on chewiness were the samples that were not blanched or subject to 80 °C.

In regard to gumminess, the tests concluded that the treatments A, B and D were statistically different from the treatments C (blanched for 10 minutes and dried at 40 ºC) and E (blanching during 5 minutes and drying at 60 ºC), with these two last showed a higher intensity, and were significantly equal to each other. On the contrary, the treatments with lower intensity were not subject to blanching or drying temperature of 80 ºC (samples A, B and D).

In regard to the last attributes studied (chewiness and gumminess); it may be observed that in the treatments C and E, the panellists associated the easiness how the samples are ground and the absence of adherence in the teeth. Souza *et al.* (2007) mentioned that texture is one of the most appreciated sensorial qualities by the fruit consumers.

It may be stated from the results obtained that the treatment with higher acceptance by the panellists was the treatment subject to blanching for 5 minutes and drying at 60 ºC (E). Blanching, in addition to avoiding the enzymatic darkness (fixing the color and texture), softens the cell tissue, increases the permeability of the cell walls, the dehydration speed and promotes the removal of the mucilaginous substances. Nieto *et al.* (2001), also state that, due to blanching, there is a diminished diffusivity, attributed to the shrinking tissue, the air expulsion and the alterations of the cell content (starch gelatinization and denaturalization of the mucilaginous substances) and these phenomena prevail on the damage of the cell wall structure and the rupture of the cell membrane that might ease the water transport.

The salt could also have contributed in the sensorial characteristics. Studying the effect of banana soaked in sodium chloride and sacarose solutions, Ehabe *et al.* (2006) found that these solutes exert a significant effect on the moisture concentration, sugar and the color index in the final product. The same authors mention that the bananas improved their appearance sensorially, when they were soaked in sodium chloride solutions. Sacchetti *et al.* (2001) found that the addition of salt in the process of osmotic dehydration in apples increases the loss of water in the product, and that the salt and sugar concentrations have a synergic effect on the impregnation of the soluble solids. Lerici *et al.* (1985) indicate that the addition of 1% of sodium chloride in the apples osmo-dehydration may help to diminish the sweetness caused by the addition of sugar in the fruit.

The sample C (blanched 10 minutes and dried at 40 ºC) had a similar acceptance similar to the sample E, in most of the attributes, except in the appearance. The sensorial profile is shown the Figure 2, where it is also observed that these treatments are also the most accepted by the panellists, supporting the results obtained by the Tukey's test. Morita *et al.* (2005) obtained a good acceptance in the crystallized products of melon, *in natura*, obtained by the slow process of sugars impregnation and further drying at 50 ºC.

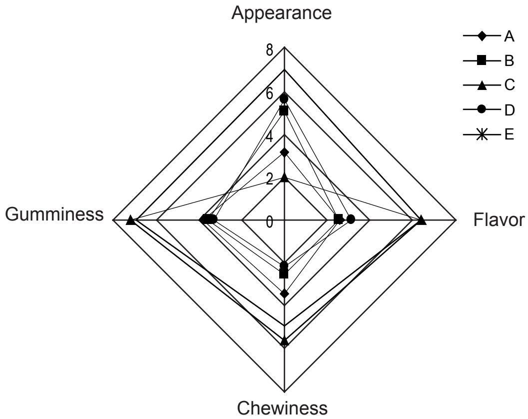

Figure 2. Sensory profile of crystallized fruits. A, samples without blanching, dried at 40ºC; B, samples without blanching, dried at 80 ºC; C, samples blanched for 10 min and dried at 40 ºC; D, samples blanched for 10 min and dried at 80 ºC; E, samples blanched for 5 min and dried at 60 ºC.

Conclusion

The treatment more accepted by the sensorial panel due to the highest intensity of the attributes evaluated, was the watermelon rind subject to blanching for 5 minutes and drying at 60 ºC during 4 hours. On the contrary, the treatments less accepted by the tasters were not subject to blanching or suffered drying temperatures of 80 ºC.

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Resumen

M. Gontero, A. Brandelli y C. Zapata Noreña. 2010. Elaboración de productos cristalizados a partir de cáscaras de sandía. Cien. Inv. Agr. 37(2): 55-60. El presente trabajo tuvo como objetivo el aprovechamiento de las cáscaras de sandía en la elaboración de productos cristalizados. Para esto fue eliminada la cutícula verde externa de la cáscara, cortadas en forma de cubo de aproximadamente 7 mm de lado, escaldado con agua en su temperatura de ebullición utilizando 0, 5 ó 10 minutos y dejados inmersos en una solución de cloruro de sodio. Posteriormente fueron sometidas a concentraciones crecientes de soluciones de sacarosa (30 a 72 °Brix) y deshidratadas en un secador a diferentes temperaturas (40, 60 y 80 °C). Los diferentes tratamientos fueron evaluados por un panel sensorial. El diseño experimental empleado fue el de bloques completos aleatorios y los resultados del análisis sensorial fueron evaluados por la prueba de comparación de medias de Tukey. Fue constatado que el tratamiento con mayor aceptabilidad, por parte del panel sensorial, fue la que había sido sometida a un escaldado de 5 minutos y deshidratado a 60 °C, cuyos valores de intensidad para la apariencia, sabor y gomosidad estuvieron entre 6 y 7.

Palabras clave: Ósmosis, sandía, deshidratación, residuo agroindustrial.

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