Effectiveness of sucrose during the frozen storage of arazá (*Eugenia stipitata* Mc. Vaugh) pulp

Uso de sacarosa como estabilizante de textura durante el almacenamiento congelado de pulpa de arazá (*Eugenia stipitata* Mc. Vaugh)

Kelly Johanna Silva-Bustos[1], Carlos Eduardo Narváez-Cuenca[1], and Luz Patricia Restrepo-Sánchez[1, 2]

ABSTRACT

The effects of sucrose on the quality of frozen arazá pulp were investigated. Five levels of sucrose (0, 5, 10, 20, and 30%) were evaluated in combination with freezing at low speed, storage during one month, and thawing at two different speeds. Sensory quality and water loss after centrifugation (WLAC) were evaluated in the samples. Before freezing sucrose addition (5-30%) to the pulp did not affect the sensory quality of the samples, but a negative effect on WLAC at 5-10% sucrose was observed. Furthermore, addition of 20-30% sucrose to arazá pulp, in combination with low speed-freezing, frozen storage, and low-speed-thawing, can be a useful technique to preserve the texture of arazá pulp. The described treatment gave results comparable to those obtained for the fresh pulp and much better than those obtained when freezing was done at high speed.

Key words: shelf life, sensory quality, texture, frozen storage, thawing.

RESUMEN

Se evaluó el efecto de la adición de sacarosa como estabilizante de textura en pulpa de arazá. Se ensayaron cinco niveles de sacarosa (0, 5, 10, 20 y 30%) en combinación con congelación a baja velocidad, almacenamiento congelado durante un mes y descongelado a dos velocidades diferentes. En las muestras se evaluó la calidad sensorial y las pérdidas de líquido por centrifugación (PLPC). El estudio mostró que la adición de sacarosa a cualquier nivel (5-30%) no afecta la calidad sensorial de las muestra; sin embargo, adiciones de sacarosa entre 5 a 10% afectaron de manera negativa los valores de PLPC. Se encontró además que una concentración de sacarosa de 20-30%, en combinación con congelado lento, almacenamiento congelado y, descongelación a baja velocidad, es una buena alternativa para conservar la textura en la pulpa de arazá. Este tratamiento dio resultados comparables a aquellos obtenidos para la pulpa fresca y mejores resultados que aquellos obtenidos cuando la pulpa fue congelada de manera rápida.

Palabras clave: vida útil, calidad sensorial, textura, almacenamiento congelado, descongelación.

Introduction

Arazá (*Eugenia stipitata* Mc. Vaugh) is a commercially promising crop for the South-East and other Colombian areas. A surface of 495 ha under arazá plantations were reported to exist in 2005; with 912 aggrupations of farmers and a total number of 247,282 shrubs (Hernández *et al*., 2007a). The fruit has a delicate flavor, with a sour and tart taste, which make it interesting for the food industry (Hernández *et al*., 2007b). Phenolics (32-35 mg galic acid/100 g FW, Vargas *et al*., 2005) and vitamin C (7-40 mg ascorbic acid/100 g FW, Hernández *et al*., 2009) have been previously reported in arazá pulp.

Because of the high water content and a lack of support tissues arazá fruit has a short shelf life (Hernández *et al*., 2007a). When the fresh fruit is marketed its shelf life is ranging from 3 to 5 d. When heat shock and refrigeration, or exposition to 1-metyl-cyclopropene and refrigeration are used it is possible to extend the shelf life of arazá fruit to up two weeks. (Carrillo *et al*., 2011; Hernández *et al*., 2009; Narváez 2003).

Marketing of arazá pulp has been proposed as a good alternative for the commercialization of the fruit (Barrera and Hernández, 1996). Freezing at low speed and storage at -20°C preserves sensory quality to up 30 d. Nevertheless, the mentioned technique induces texture loss as observed from the beginning of the frozen storage, which dramatically affects the quality of the pulp after the first month of storage at -20°C (Mejía *et al*., 2006). Freezing at high speed by liquid nitrogen in combination with thawing at low speed has been described as an option to smooth the speed of texture degradation of arazá pulp (Millán *et al*., 2007).

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[1] Department of Chemestry, Faculty of Sciences, Universidad Nacional de Colombia. Bogota (Colombia).
[2] Corresponding author. lprestrepos@unal.edu.co

It is known that freezing at low speed induces growing of ice crystals that brake the cell and that during thawing those broken cells loss their texture. On the other hand, freezing at high speed does not induce ice crystal growing and therefore lower negative effects are observed on the texture during thawing (Rosenthal, 2001).

To avoid negative changes in the texture of fruit products such as nectars it is possible to use texture stabilizers (e.g. carboxymetylcelullose or gums); nevertheless, according to the Colombian legislation, their use in pulp fruits is prohibited (NTC 5468, Icontec, 2007). The cited regulation allows the use of sugars such as sucrose and glucose in pulp fruits. The inclusion of sugars might improve the stability of the texture during freezing and thawing of fruit pulps as a result of the interaction between sugars and pectin, present in pulps (Labuza, 1977).

Information shown above indicates that freezing at high speed and thawing at low speed are suitable to control texture degradation during frozen storage of arazá pulp. Taking into account that freezing at high speed requires relatively more sophisticated infrastructure than freezing at low speed, this work was aimed to test the effectiveness of sucrose in the control of the texture of arazá pulp frozen at low speed. Therefore, the effect of both, several concentrations of sucrose, and the thawing speed on the texture as measured as sensory texture (by a trained panel), and as instrumental texture (water loss after centrifugation) during storage of arazá pulp at -20°C during 30 d was evaluated.

Materials and methods

Plant material

Ripe and visibly undamaged arazá fruits were washed with tap water and peeled by hand. After removing the seeds the pulp was homogenised during 10 s in a household blender.

Storage experiments

Storage was performed according to a randomized block design, with five treatments (five different concentrations of sucrose) and two blocks (two speeds of thawing). Each combination treatment X block consisted of three replications of 150 g of arazá pulp. Arazá pulp was mixed with sucrose to get concentrations of 0, 5, 10, 20, and 30% sucrose/total material, w/w. Samples were dispensed in polyethylene bags with hermetic sealing. Afterwards, samples were frozen at low speed and stored at -20°C. For comparison purposes, a control sample, without sucrose addition, was frozen at high speed by immersion in liquid nitrogen. Samples were stored at -20°C over a period of one month. After 15 and 30 d of frozen storage samples were removed from the freezer and thawed under two different conditions. In the first condition, samples were thawed at low speed at room temperature. In the second situation, samples were thawed at high speed by microwave (400 W, 40 s). Samples were analysed at day 0, before freezing, and at days 15 and 30, after thawing. Sensory evaluation and water loss after centrifugation were evaluated.

Sensory analysis

Sensory analysis was done by five trained panelists from the Universidad Nacional de Colombia. Quantitative descriptive analysis was performed to evaluate the effect of both the concentration of sugar and the speed of thawing on the general aspect and color, aroma, and texture of the arazá pulp samples. The evaluation was done in a room specifically designed for sensory evaluation with individual booths and controlled white light. In the first session (day 0), five panelists tested 15 samples (three replications from the five levels of sugar: 0, 5 10, 20, and 30%). Analysis of samples after 15 d of frozen storage was performed in two consecutive days. During those two sessions, five panelists tested a total of 36 samples (three replications from the five levels of sugar, freezing at low speed, thawing at low speed; three replications from the five levels of sugar, freezing at low speed, thawing at high speed; three replications from the no sugar, freezing at high speed, thawing at low speed treatment and; three replications from the no sugar, freezing at high speed, thawing at high speed treatment). A similar scheme of two sessions was employed for the analysis of the samples after 30 d of frozen storage. Each panelist was asked to rate the quality of the pulp according to the structured scale described in Tab. 1. Total quality was calculated as the sum of the individual scores.

TABLE 1. Scores and descriptors during the sensory evaluation of arazá pulp.

Score	Description
	General Appearance and Color
3	Brilliant yellow color, presence of fibres and very homogenous material
2	Yellow, no brilliant, dark color, disintegrated material
1	Slight yellow or dark brown, no homogenous material, pasty
	Aroma
2	Strongly acidic, fruity, ripe, fresh
1	Poor acidic, herbal, fermented
0	Weakly fruity, extremely fermented, atypical, mouldy, metallic
	Texture
5	Viscous, juicy, soft, presence of fibres, adherent, consistent, homogenous
3	Viscous, slightly juicy, soft, presence of fibres, no homogenous, lumpy
1	Disintegrated, separation of phases, extremely fluid

Water loss after centrifugation (WLAC)

The WLAC was measured by centrifugation of 10 g-samples at 3,000 rpm during 10 min. Volume of liquid released after centrifugation was measured and WLAC values were expressed as %, v/w (Millán *et al*., 2007).

Data analysis

Results of sensory analysis are reported as the mode and analysed by the non-parametric Kruskall-Wallis-test. Water loss after centrifugation (WLAC) results are reported as the mean and their standard deviation. An ANOVA according to a randomized block design was performed on the results of WLAC. Comparisons among means of WLAC results were performed by Fisher-test.

Results and discussion

Sensory characteristics and water loss after centrifugation (WLAC) results are shown in Tab. 2. In the fresh pulp, before freezing, sucrose addition (0-30%) did not affect the sensory quality of the samples ($P<0.05$). Nevertheless, WLAC values were increased at 5-10% sucrose, which suggest that sucrose at concentrations between 5 to 10% negatively affected the texture of the pulp samples.

General appearance and color of samples without sucrose was not affected by the storage time (when freezing at low speed) nor by the speed of thawing. In contrast, aroma and sensorial texture were negatively changed by the frozen storage. This effect was independent of the speed of thawing. In the same samples WLAC data indicates that frozen storage negatively affected the texture, similar to what was observed for the sensorial texture. Interestingly, thawing at high speed had a stronger negative effect on the WLAC if compared to those data obtained when thawing was done at low speed. These results agree with those previously reported by Millán *et al*. (2007). The mentioned authors suggested that thawing at low speed enhanced the re-absorption of liquids capability by the pulp and then,

TABLE 2. Sensory characteristics and water loss after centrifugation (WLAC) of arazá pulp-Effect of sucrose concentration, frozen storage and thawing speed.

Treatment	General appearance and color	Aroma	Texture	Total quality	WLAC (%, v/w)
		Fresh pulp			
Sucrose 0%	3 aA	2aA	5 aA	10 aA	21.0±3.7 cD
Sucrose 5%	3 aA	2 aA	5 aA	10 aA	27.2±3.2 bD
Sucrose 10%	3 aA	2 aA	5 aA	10 aA	31.7±4.3 aB
Sucrose 20%	3 aA	2 aA	5 aA	10 aA	23.7±4.8 bcBC
Sucrose 30%	3 aA	2 aA	4 aA	9 aA	22.6±4.5 cA
		15 d of frozen storage, thawing at high speed			
Sucrose 0%	2 aA	2 aA	2 bB	6 bC	59.9±6.1 aA
Sucrose 5%	2 aB	2 aA	3 bB	7 bC	34.9±5.4 bC
Sucrose 10%	3 aA	2 aA	5 aA	10 aA	35.7±3.7 bA
Sucrose 20%	3 aA	2 aA	4 aA	9 aA	28.0±2.8 cA
Sucrose 30%	3 aA	2 baA	4 aA	9aA	21.7±3.9 dA
		15 d of frozen storage, thawing at low speed			
Sucrose 0%	3 aA	2 aA	3 bB	8 bB	49.9±4.5 aC
Sucrose 5%	3 aA	2 aA	3 bB	8 bB	40.7±2.0 bB
Sucrose 10%	3 aA	2 aA	3 bB	8 bC	31.2±4.0 cB
Sucrose 20%	2 aA	2 aA	5 aA	9 aA	25.6±0.3 dB
Sucrose 30%	3 aA	2 aA	4 aA	9 aA	21.6±4.5 eA
		30 d of frozen storage, thawing at high speed			
Sucrose 0%	2 bA	1 bB	3bB	6 cC	60.0±3.8 aA
Sucrose 5%	3 aA	2 aA	3 bB	8 bB	37.2±1.1 bC
Sucrose 10%	3 aA	2 aA	4 bB	9 abB	29.0±4.6 cB
Sucrose 20%	3 aA	2 aA	5 aA	10 aA	28.2±1.2 cA
Sucrose 30%	3 aA	2 aA	5 aA	10 aA	21.2±4.6 dA
		30 d of frozen storage, thawing at low speed			
Sucrose 0%	3 aA	1 bB	3 bB	7 bC	54.4±4.3 aB
Sucrose 5%	3 aA	2 aA	4 aB	9 aB	45.2±6.4 bA
Sucrose 10%	3 aA	2 aA	4 aB	9 aB	38.3±1.1 cA
Sucrose 20%	3 aA	1 bA	5 aA	9 aA	22.8±3.4 dC
Sucrose 30%	3 aA	2 aA	4 aA	9 aA	16.1±0.0 eB

products with better quality are obtained if compared to pulp thawed at high speed.

Sucrose addition to the pulp samples, independent of its concentration (5-30%), prevented degradation of general appearance and color, and aroma during frozen storage. A closer range was found to be optimum when the sucrose concentration effect was studied on the sensorial texture and on the WLAC. Concentrations of sucrose ranging from 20 to 30% were found suitable on the maintenance of the texture during storage. Furthermore, addition of sucrose at 20-30% previous to frozen storage, in combination with thawing at low speed, gives better results if compared to similar sucrose concentrations but with thawing at high speed.

Lower case letters indicate differences ($P \leq 0.05$) between sucrose levels in the same day of frozen storage/thawing. Capital letters indicate differences ($P \leq 0.05$) between frozen storage/thawing treatment at the same sucrose level.

High speed-freezing/low speed-thawing, 15 d: general appearance and color, 2; aroma, 1; texture, 2; total quality, 5; WLAC, 60.6±1.5. For 30 d: general appearance and color, 2; aroma, 1; texture, 2; total quality, 5; WLAC, 55.0±2.5.

High speed-freezing/high speed-thawing, 15 d: general appearance and color, 2; aroma, 1; texture, 2; total quality, 5; WLAC, 56.9±2.1. For 30 d: general appearance and color, 3; aroma, 1; texture, 3; total quality, 7; WLAC, 56.1±1.9.

Previously, it was reported that freezing at high speed, frozen storage, and thawing at low speed is more suitable than freezing at low speed regarding the WLAC of arazá pulp (Millán *et al*., 2009); nevertheless, those results showed that under those conditions the degradation of the texture was not completely inhibited, since 15 d-frozen arazá pulp, which was frozen at high speed and thawed at low speed, gave WLAC values that were 35% higher than those of the fresh-untreated pulp. In the current research we found that the WLAC values by applying the combination high speed-freezing, frozen storage during one month, and low speed-thawing (55.0±2.5) were similar to those of the combination low speed-freezing, frozen storage during one month, and low speed-thawing (54.4±4.3). In contrast, 20% sucrose in combination with low speed-freezing, frozen storage during one month, and low speed-thawing gave better WLAC results (22.8±3.4), as this value is similar to that obtained for the un-frozen fresh pulp (21.0±3.7). Results obtained with 30% sucrose were comparable to those at 20% sucrose.

Results shown above point out at the positive effect that the use of sucrose has on the aroma, sensorial texture, and physical texture (evaluated as WLAC) during frozen storage. The protective effect of sucrose over the aroma of pulps might be related to the control of the water activity, and on the control of enzymes such as lypoxygenase; enzyme that has been related to off-flavor production (Coelho et al., 2007). Sucrose has also been linked to a direct protective effect on volatile compounds in food systems (Friel *et al*., 2000).

Pectin content has previously been determined in ripe arazá fruit (0.4%), with a ratio 2 to 1 when comparing high methoxyl pectin to low methoxyl pectin (Filgueiras *et al*., 2002). Stabilization of the texture of arazá pulp samples containing 20-30% sucrose is in close relationship to the stabilizing effect of sucrose on high methoxyl pectin gels at low pH (Labuza, 1977). Because of the relatively high amount of hydroxyl groups in sucrose, it is considered that sucrose is able to form hydrogen bonds with water and with pectin, thus allowing the system to stabilize by forming a linked network of molecules.

Conclusions

During pulp fruit processing one of the task is to get final products with sensory and nutritional characteristics similar or even better to those of the fresh fruit. Addition of 20-30% sucrose to arazá pulp, in combination with low speed-freezing, frozen storage, and low-speed-thawing, was found to be a good alternative to preserve the texture of arazá pulp. With that combination both sensory characteristics and WLAC data were similar to those of the fresh pulp. Furthermore, the combination 20-30% sucrose/freezing at low speed was more effective in controlling texture degradation of arazá pulp than freezing at high speed.

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