Effect of pH on Texture and Organoleptic Evaluation of Citron Fruit Bars Packed in Plastic Film[1]

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ABSTRACT

Citron fruit bar is a product similar to the bitter orange preserve; both use sugar to produce a thin crust and a soft inner portion. The crust, due to continued crystallization, increases in thickness until the whole bar has a hard crystallized structure. Citron bars processed at a pH of 3.4 to 4.4 showed that the amount and rapidity of crystallization can be controlled to obtain a preserve which keeps the desired texture for a longer time during storage. The most acceptable product, a bar with a thin crust and a soft inner portion which maintained these characteristics for more than six months, was obtained when the citron bar was processed at pH 4.1.

INTRODUCTION

There is scarcely a field in food science and technology where the pH of the product is not important. The properties of fruit jellies depend on the pH, the optimum being about 3.3 for some pectins and 3.1 for others, while the practical limits are 3.1 to 3.55. Above 3.55 the fruit may not form a jelly, while below 3.1 the jellies are soft and weaker and syneresis may result (6). In bread, pH influences the diastatic activity which affects the texture of the finished product. In the manufacture of syrup and other products containing sugar the pH level controls the inversion of sucrose, thus affecting the viscosity of the final product (4).

In fruit bars, texture is the result of pectin content (type and amount, naturally occurring or added), nature and amount of the fruit pulp added, the sugar content and the pH level. This paper reports on further aspects of texture changes of citron fruit bar components due to variations in pH during preparation.

MATERIALS AND METHODS

Citron fruit bars were prepared according to the method described by Cancel and Hernández (1) except for the operation related to the addition of citric acid. For this study citric acid was added to the mixture of citron pulp, sugar, pectin and water before starting the boiling operation. In order to add the proper amount of citric acid, a small portion of the citron pulp, sugar, water and pectin mixture was homogenized in a

[1] Manuscript submitted to Editorial Board August 30, 1976.

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blender for 2 min. A weighed sample of this mixture was titrated with a citric acid solution to the desired pH. Calculations were then made to determine the total amount of citric acid necessary to bring the batch to be processed to the specified pH, and it was added to the mixture dissolved in a small amount of water. The pH of the mixture was determined in order to check the resulting pH value. After making any necessary adjustments, heat was applied to start the boiling process.

Two drying systems were used to form and stabilize the citron bar. Three lots were dried in a controlled atmosphere chamber with 44–48% relative humidity and 75° F temperature; four lots were dried in an air conditioned room with 50% relative humidity and 72° F until the surface of the bars was dry enough for handling. In general, drying the lots took 30 to 48 h, depending on the pH; bars with a low pH took more time than those with a high pH.

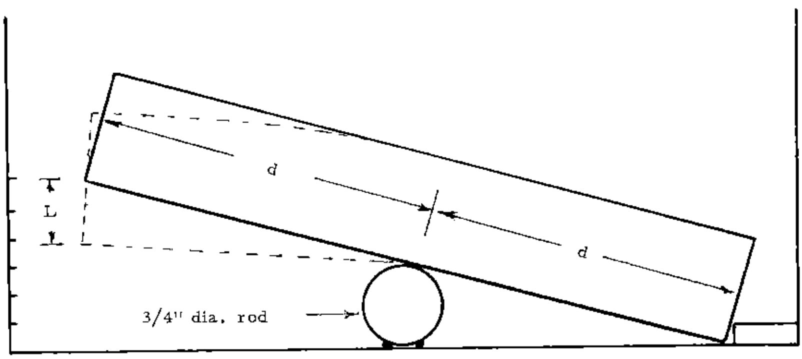

FIG. 1.—Schematic drawing of apparatus to measure firmness of citron fruit bar.

Using the method described, bars were prepared with pH values of 3.1, 3.4, 3.7, 4.1, and 4.3.

The bars were wrapped in commercial household Saran[3] laminate, packed in corrugated cardboard boxes, and stored in an air conditioned room at about 82° F.

A lot prepared using glucose and sucrose in a 1:3 ratio, and with no pH control, was stored for comparison.

An Allo-Kramer shear press equipped with a peak shear compression cell (CS-1) was used to measure the compression and shearing force of the fruit bar.

[3] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

Samples of the citron preserve were cut to fit the area of the compression-shearing cell. Since the thickness of the fruit bar was fixed by the standard aluminum molds used in the processing operation, this measure was assumed to be the same for all the samples.

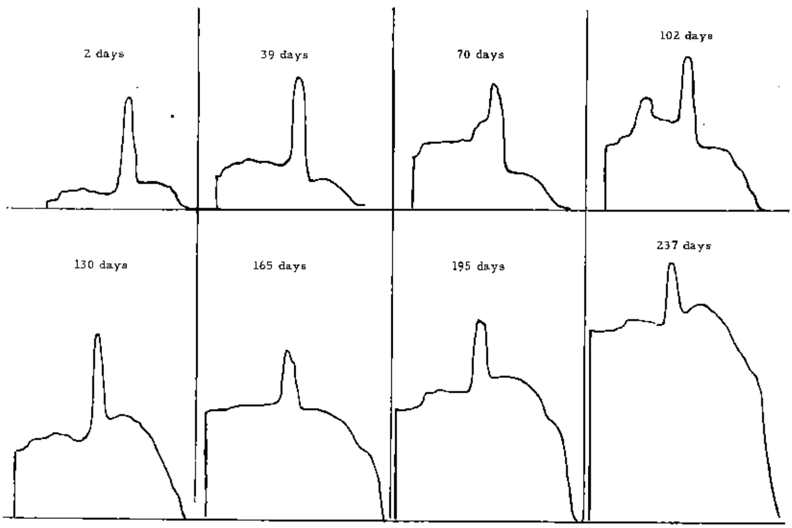

FIG. 2.—Texturegrams at different storage periods of citron fruit bar with pH of 3.4.

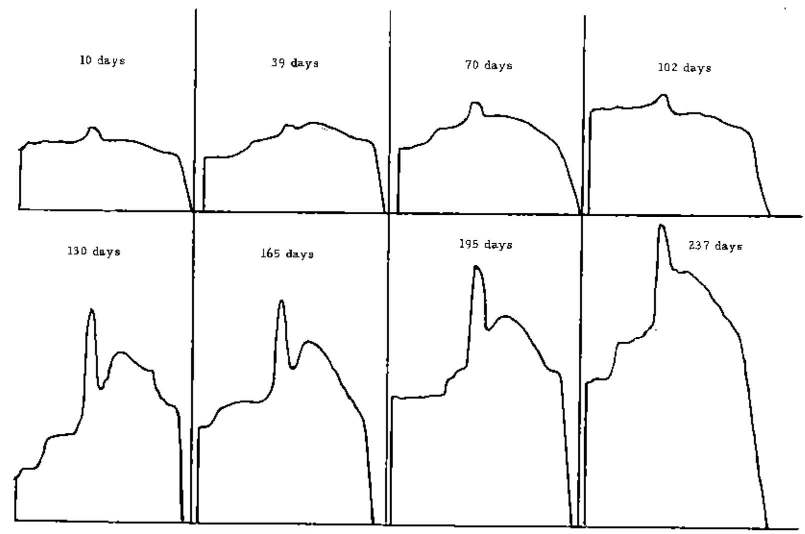

FIG. 3.—Texturegrams at different storage periods of citron fruit bar with pH of 3.7.

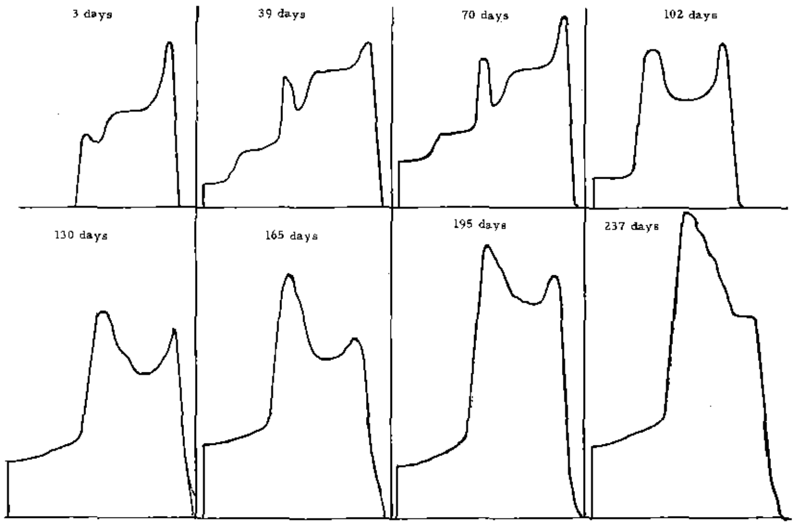

FIG. 4.—Texturegrams at different storage periods of citron fruit bar with pH of 4.1.

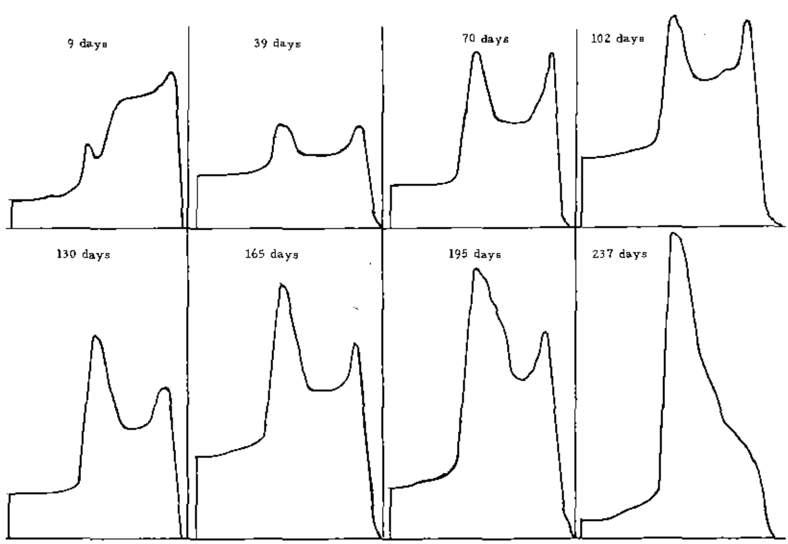

FIG. 5.—Texturegrams at different storage periods of citron fruit bar with pH of 4.3.

The Allo-Kramer shear press was also equipped with a recorder, which graphed a complete extrusion curve of the test performed with the preserve.

A deformation or bending test was carried out on the bars after 20 days of storage. Figure 1 shows the apparatus used. On placing the fruit bar midway on the long dimension, the bar deflects downward depending on the firmness of the gel structure. The length of "L" of the deflection was recorded after 1 min exposure.

Fruit bars were cut crosswise in the middle with a sharp knife using a sawing motion. This gave a clean transversal view of the crust formed. Crust formation was evaluated as: No crust, fairly or just perceivable crust, $^1/_{16}$ in crust, $^1/_8$ in, and over $^1/_8$ in crust. The whole sliced fruit bars showing crust formation at a given storage period were photographed.

Organoleptic evaluations of the citron preserve were made using a six-point hedonic scale in rating them according to appearance and texture.

RESULTS AND DISCUSSION

The visual evaluations and firmness tests after a 20-day storage showed that bars with pH 3.1 were soft, had round edges, and did not retain the shape given by the aluminum mold. The product had a tendency to spread out on standing without the plastic film wrap. The surface was sticky to such an extent that handling was difficult. This product (pH 3.1) was discontinued because it had no commercial purpose.

Bars with pH 3.4 were soft but kept their shape. A one-minute test of their firmness or rigidity showed a deflection or bending of $^1/_2$ in. No crystallization was observed at this stage.

Bars with pH 3.7 looked like the pH 3.4 bars but were more rigid, having a deflection of $^1/_4$ in for a 1 min test. No crystallization was observed in this product.

Bars with pH 4.1 had a fairly perceivable crust, showing that crystallization had just started. There was no deflection after a 1 min test.

With pH 4.3, bars had a thin crust, about $^1/_{16}$ in, but in some spots this crust looked as if the crystals were clustering or increasing in thickness. The product showed a more advanced stage of crystallization. There was no deflection when subjected to the rigidity test for 1 min.

Figures 2, 3, 4, and 5 show texturegrams of the fruit bars processed with pHs, 3.4, 3.7, 4.1, and 4.3, respectively, and stored for different periods. The curves show: Gel strength as measured by the peak force value; deformation force as measured by the distance from the beginning of the curve to the first peak; firmness as indicated by the average height of the curve; and uniformity of the gel structure as measured by the slope and smoothness of the profile of the curve.

The curve for fruit bars with pH 3.4 shows that no crust was formed. Only a maximum well-defined peak is produced and this occurs too far from the beginning of the curve to indicate crust formation. Fruit bars processed with pH 3.7 had curves with a smoother profile than those at pH 3.4, but the total work in compression and shearing is higher. The latter can be calculated from the curves in figures 2 and 3, and is numerically confirmed by the graph in figure 6, where the total work and the maximum force during the test cycle are plotted for each of the fruit bars prepared at a different pH.

Texturegrams of fruit bars with pH levels of 4.1 and 4.3 presented in figures 4 and 5 show a change in curve outline. There is a short compression stage at the beginning of the curve with a steep slope and a pronounced peak. The first pronounced peak is followed by a drop in the curve and later on with another distinct peak. This type of curve was

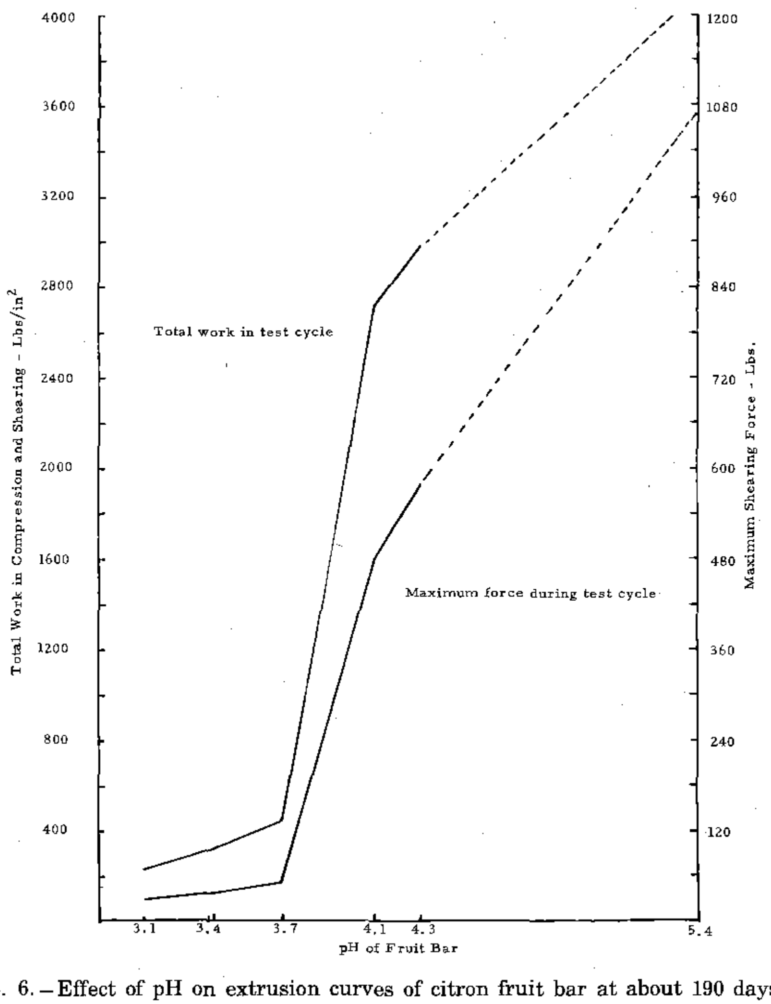

FIG. 6.—Effect of pH on extrusion curves of citron fruit bar at about 190 days of storage. Fruit bars dried in controlled atmosphere chamber with forced draft.

found to be characteristic of bars with a definite crust on both sides. The curves from preserves at pH 4.1 and 4.3 stored for 237 days produced a typical curve with only one peak, but associated with a high maximum force of 540–600 lbs. This was found to be related to the amount of sugar crystallization which had already occurred throughout the bar and which eliminiated the soft inner portion between the surface crusts. These bars were almost solid with sugar crystals, an undesirable condition in citron bars.

Figure 6 shows the total work and maximum force curves for the samples with pH 3.4, 3.7, 4.1, and 4.3 at about 190 days of storage. It also indicates that the maximum force peak is a satisfactory index of the rheological properties of the fruit bar. In the determination of the rheological characteristics of fruit bars it is not mandatory to calculate the area under the curve to find the total work done during the test cycle in order to determine the texture quality of the bar. This finding agrees with Kramer's suggestion for the determination of texture quality in jellies, puddings, and other gel type products (2, 3).

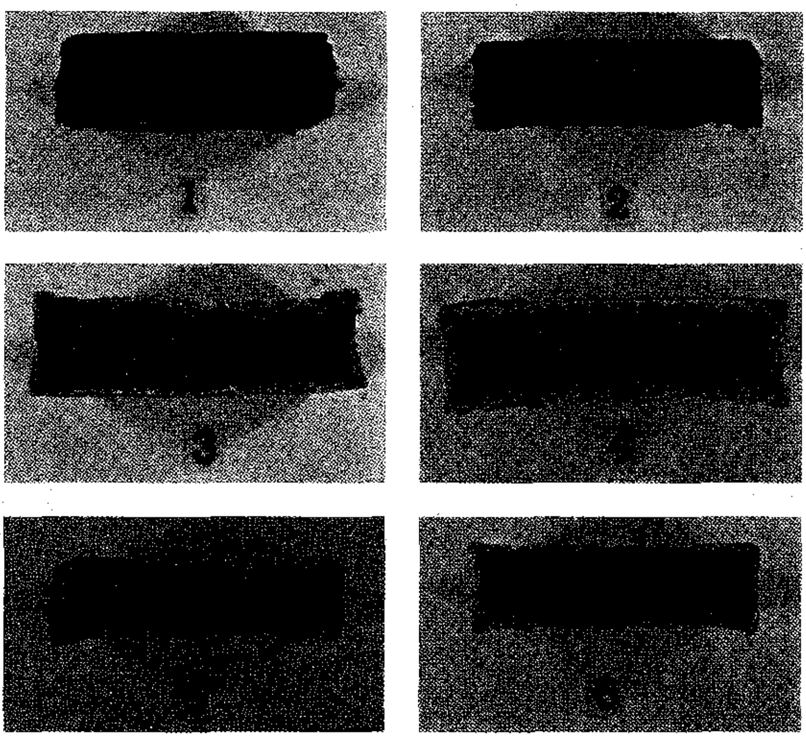

FIG. 7.—Citron fruit bars sliced in halves showing crystallization and characteristics of inner soft portion. No. 1 was processed at pH 3.4; No. 2 at 3.7; No. 3 at 4.1; and No. 4 at 4.3; all stored for 199 days. No. 5 at pH 4.1, stored for 283 days; No. 6 at 5.1, processed with a mixture of glucose and sucrose (1:3 ratio), stored for 352 days.

The dotted line section of the curves in figure 6 shows the difference between bars made at controlled pH (3.4, 3.7, 4.1, and 4.3) and those made without controlled pH which always was from 5.0 to 5.8, depending on the ripeness of the fruit used.

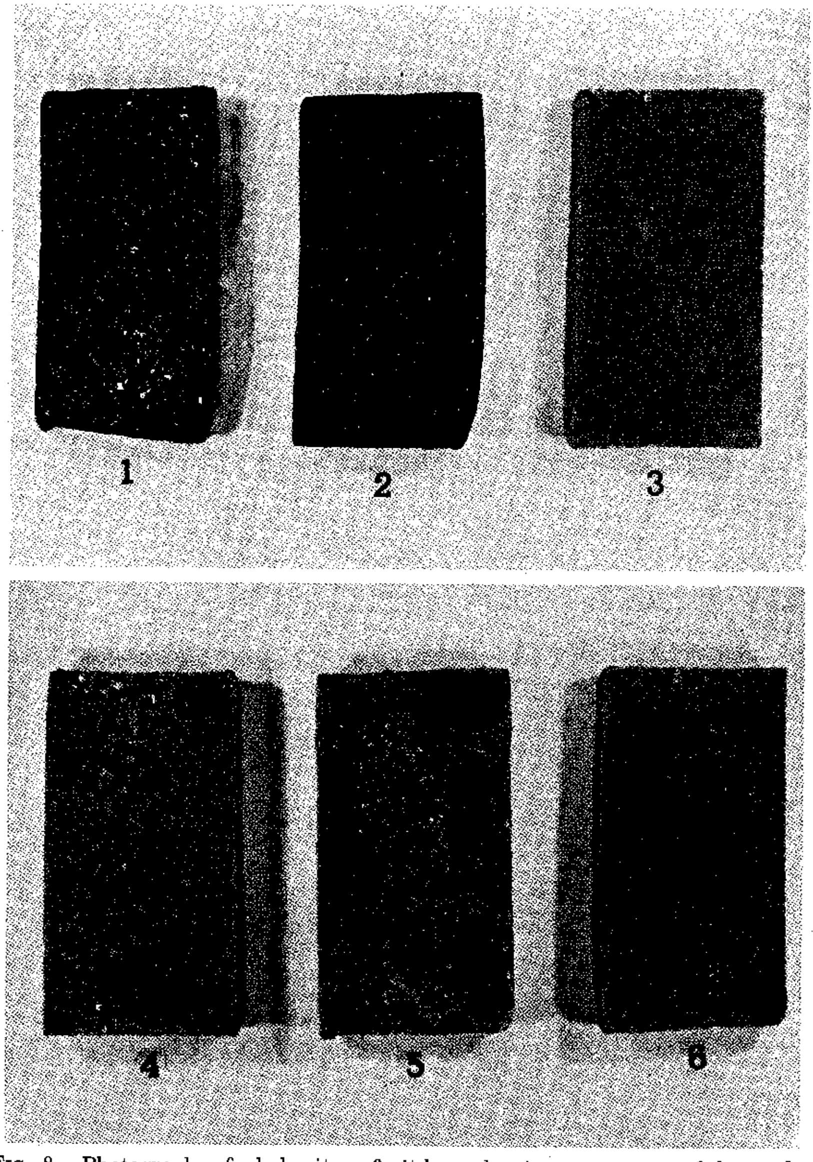

FIG. 8.—Photographs of whole citron fruit bars showing appearance of the product. No. 1 was processed at pH 3.4; No. 2 at 3.7; No. 3 at 4.1; and No. 4 at 4.3; all stored for 199 days. No. 5 at pH 4.1, stored for 283 days; and No. 6 at 5.1, processed with a mixture of glucose and sucrose (1:3 ratio), stored for 352 days.

Figures 7 and 8 show fruit bars processed at different pH levels, stored for more than 6½ mo, and photographed to record the appearance of the product. Sample 1 was processed at pH 3.4; No. 2 at 3.7; No. 3 at 4.1, and No. 4 at 4.3. All were stored for 199 days. No. 5 had a pH of 4.1 and was stored for 283 days; No. 6, pH 5.1, was processed with a mixture of glucose and sucrose (1:3 ratio) and stored for 352 days.

Samples 1 and 2 did not form crust. The color of bar 1, by the Munsell Color Classification, was 5 YR 6/8; No. 2 was 5 YR 5/6. The caramel color was more intense at the edges, bar No. 2 having the color more accentuated.

Samples 3, 4, and 5 had a crust; No. 3 had less crust or crystallization than No. 4; and No. 4 had less than No. 5. The thickness of the crust in No. 3 is more or less 1/16 in on the smooth surface; No. 4 and No. 5 had about 1/8 and 1/4 in, respectively.

The inner soft portion of sample 3 had no crystallization; No. 4 had some spots, while No. 5 had more than three times the number of crystallization spots exhibited by No. 4. The Munsell Color Classification for the inner soft portion was 7.5 YR 6/10 for sample 3 and 7.5 YR 7/6 for No. 4 and 5, but No. 5 was completely filled with sugar crystal clusters.

Sample 6 had a crust between 1/16 and 1/8 in and did not have crystallization spots in the inner soft portion. The Munsell Color Classification was 7.5 YR 5/8.

Organoleptic tests showed total acceptance for all fruit bars prepared, but the bar prepared with pH 4.1 was always preferred by the panelists because of its texture, a thin crust, and a soft inner portion.

RESUMEN

La pasta de cidra es similar a la de naranja. Las dos se preparan usando sacarosa de tal forma que se logre una cristalización fina en la superficie y una masa interior blanda. En el producto que se prepara comercialmente el azúcar tiende a continuar cristalizándose hasta formar una pasta totalmente cristalizada y dura después de 1 ó 2 meses de almacenamiento. Por eso se estudió el efecto de los niveles de pH durante la preparación de pastas de cidra confeccionadas totalmente con sacarosa sobre las propiedades de almacenamiento. Al empezar el trabajo se prepararon lotes de pastas variando el pH de 3.0 a 5.0. De su evaluación se determinó estudiar los efectos de pH 3.1, 3.4, 3.7, 4.1 y 4.3.

A los 20 días de preparadas las pastas se evaluaron. Los resultados demonstraron que la pasta con pH de 3.1 era demasiado blanda para entrar en el mercado. Además de blanda era pegajosa y no cortaba bien; se descartó. La pasta a pH 3.4 mantenía la forma pero aún quedaba muy blanda. En la prueba de rigidez experimentó una flexión de ½ pulgada. La pasta a pH 3.7 se parecía mucho a la de pH 3.4 pero era más consistente, pues en la prueba de rigidez la flexión fue de ¼ pulgada. Las pastas a pH 3.4 y 3.7 no acusaban cristalización. A pH 4.1 y 4.3 las pastas mostraban cristalización en la superficie, pero apenas se notaba en la pasta a pH 4.1; la de pH 4.3 tenía una capa como de 1/16 pulgada de gruesa. Las dos eran completamente rígidas, aptas para una fácil manipulación al empacarse.

Estudios de textura con la prensa Allo-Kramer demonstraron que el grado de cristalización en estas pastas se puede determinar mediante la curva de fuerza registrada por el instrumento. El perfil de esta curva da un índice de la formación de la cristalización; el pico más amplio de la curva registra la dureza de las capas azucaradas que se han formado.

La evaluación de las pastas después de 6 meses almacenadas demonstró que a pH 3.4 y 3.7 no se formaba cristalización durante ese tiempo. A pH 4.1 y 4.3 sí cristalizaron; la de pH 4.1 tenía una capa como de 1/16 pulgada, mientras que la de pH 4.3 tenía como 1/8 pulgada con algunas áreas de 1/4 pulgada de espesor.

Del estudio se desprende que al elaborar pastas de cidra éstas deben confeccionarse a un pH de 4.1 para lograr la adecuada cristalización.

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