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Effect of rehydration on texture properties of Mexican plum (*Spondias purpurea* L.) dehydrated by tray drying and freeze drying

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Abstract
Mexican plum (Spondias purpurea L.*) is a fruit with high nutritional content. Freeze and tray drying increases its shelf life, however non-reversible changes may ocurr. Properties as rehydration capacity and texture are considered as a measure of the injury to the material caused by drying. In this sense, the objective of this research was to evaluate the texture profile of dehydrated plum during rehydration and compare it with properties of raw plum. Freeze drying provided a product with less tissue damage reflected in the high rehydration capacity and texture characteristics very close to original unlike those dehydrated by hot air.*

Keywords: *Mexican plum; rehydration; texture profile analysis.*

1. Introduction

Mexican plum (*Spondias purpurea* L.) is a fruit with qualities and potential for many different applications in the food industry. Nevertheless, the plums are mainly commercialized in local markets and have an incipient postharvest management with few methods for postharvest conservation currently in place [6]. Drying techniques, as freeze drying and tray drying, can be an excellent alternative to make their shelf-life longer and commercialization easier. It allows conversion of perishable materials into stabilized products by lowering water activity to appropriate levels, thus preventing microbial spoilage and quality deterioration [7].

Freeze drying prevents undesirable shrinkage and produces materials with high porosity, good nutritional quality, superior texture, aroma, flavor and color retention [10]. In contrast, tray drying is the most widely employed method for preserving food materials because of its simplicity and low cost that demands small investments for industries. It is commonly used for drying fruits and vegetables using hot air as a carrier of heat [12].

Despite advantages of preserving foodstuffs, drying methods may cause many non-reversible physical and chemical changes in the material such as color, nutritional value, shrinkage, texture etc. [3] Thus, rehydration can be considered as a measure of the injury to the material caused by drying and treatments preceding dehydration [5]. According to Farahnaky and Kamali the ultimate objective of rehydration process is to obtain a product with textural properties similar or close to original [4].

Textural properties of a food are that group of physical characteristics that arise from the structural elements of the food, are sensed primarily by the feeling of touch, are related to the deformation, disintegration, and flow of the food under a force, and are measured objectively by functions of mass, time, and distance [2]. It is known that the sensations experienced as the food material deforms and fractures during the initial stages of biting/chewing govern our acceptance or rejection of the product [1]. In this way, textural parameters can be considered as an attribute to assess acceptability and quality of products.

There are few studies of textural properties of dried and rehydrated foodstuffs, in special Mexican plums. Thus, the purpose of this work was to study the evolution of texture properties during rehydration process of plum slices dehydrated by tray drying and freeze drying.

2. Materials and Methods

2.1 Raw material

Mexican plums ("beetroot" ecotype) were obtained from Orizaba and Coscomatepec, Veracruz, Mexico and selected according to the ripening degree (30 % green, 70 % red).

The plums were washed and cut into slices of 3 cm of diameter and 0.2 cm of thickness for tray drying (TD) and 1.4 cm of diameter and 0.2 cm of thickness for freeze drying (FD). For freeze drying, the plum slices were frozen at -20 °C during 2 hours.

2.2 Drying process

Hot air drying was performed in a pilot scale vertical tray dryer (MOD-SEM-2 Polinox, MX) at air temperature of 53 °C during 4.5 h. The freeze drying was conducted in a laboratory scale dryer (Mod-742004 Labconco, USA) at 0.1 mbar vacuum pressure during 4.3 h [10].

2.3 Texture Profile Analysis

The texture profile analysis (TPA) was performed on fresh, dehydrated and rehydrated slices of plum using a Texture Analyzer (CT3-100, USA). TPA involved properties as hardness, cohesiveness, springiness and adhesion and was carried out by two compression cycles and operating conditions of the equipment were selected according to the drying method applied in order to reach a right compression of the product. Cylindrical probes were used to perform TPA tests (25.4 mm diameter, 35 mm length for TD; 12.7 mm diameter, 35 mm length for FD). Table 1 shows operating conditions used for each size of slice, with its respective drying method.

Table 1. Operating TPA conditions

	Tray drying		Freeze drying	
Operating conditions	**Fresh/ Rehydrated**	**Dehydrated**	**Fresh/ Rehydrated**	**Dehydrated**
Trigger (N)	0.01471	0.01471	0.01471	0.01471
Deformation (mm)	1	1	2	1
Speed (mm/s)	1.2	1	1.5	1

Rehydration of plum slices was performed in water and milk at 10, 20 and 30 °C. For TPA test an amount of 7 slices were added to the immersion media. Every 5, 10, 15, 20, 25, 30 and 35 min a different slice was taken out, drained in absorbent paper and set in the texture analyzer to measure the texture parameters during rehydration. Every experiment was made by triplicate.

3. Results and discussion

3.1 Texture analysis of rehydrated freeze dried plums

Differences on texture properties during rehydration (Fig. 1 and 2) can be attributed to the swelling and the leaching of solubles also these results can be explained based on the fact that at short times of rehydration, samples are not still equilibrated with the presence of great gradients of moisture content from surface to centre [9] and in consequence, affecting to the measure of texture profile.

Graphics (Fig. 1 and 2) show texture properties of freeze dried plum during rehydration and its variation with respect time. Analysis of variance (ANOVA) and the test of mean comparison (Dunnett) were conducted with a level of significance of 0.05. Texture properties of fresh plum were selected as the control. Final value of hardness (water, 10 °C) had no significant differences compared with fresh plum. In contrast there were significant differences at higher rehydration temperatures.

With respect to rehydration in milk, final values of hardness remained unchanged at the end of rehydration process with every temperature. Cohesiveness at 10 and 30 °C of plum rehydrated in water showed similar values than non-dried plum. On the other hand, rehydration in milk allowed to reached final cohesiveness values with no significant difference for all the temperatures used.

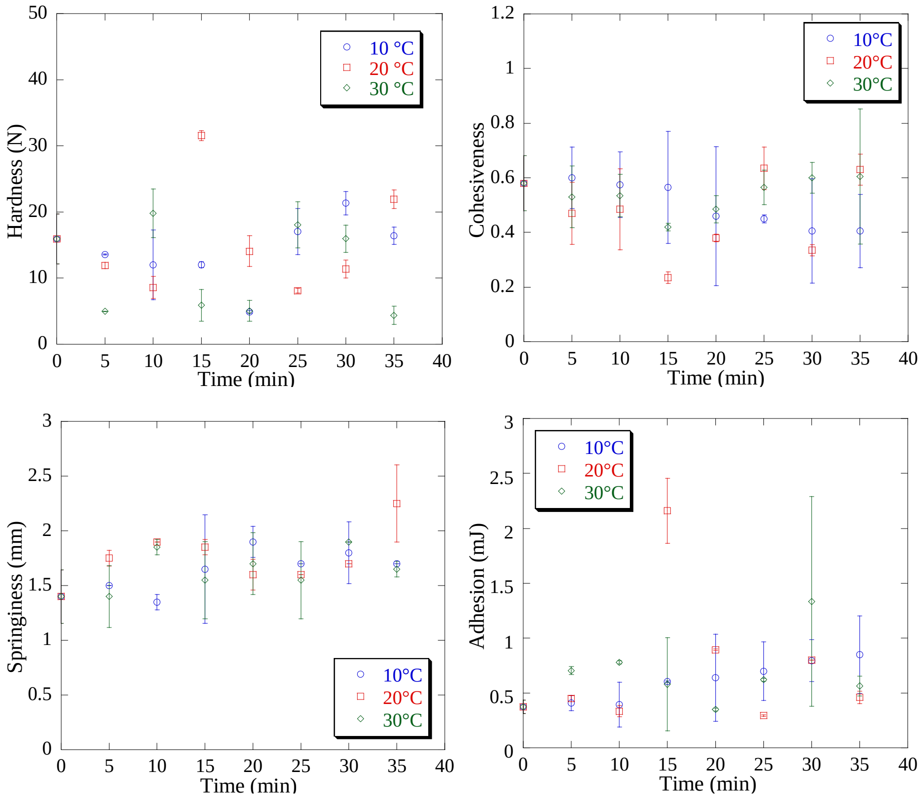

Fig. 1 Textural properties during rehydration of freeze dried plum immersed in water.

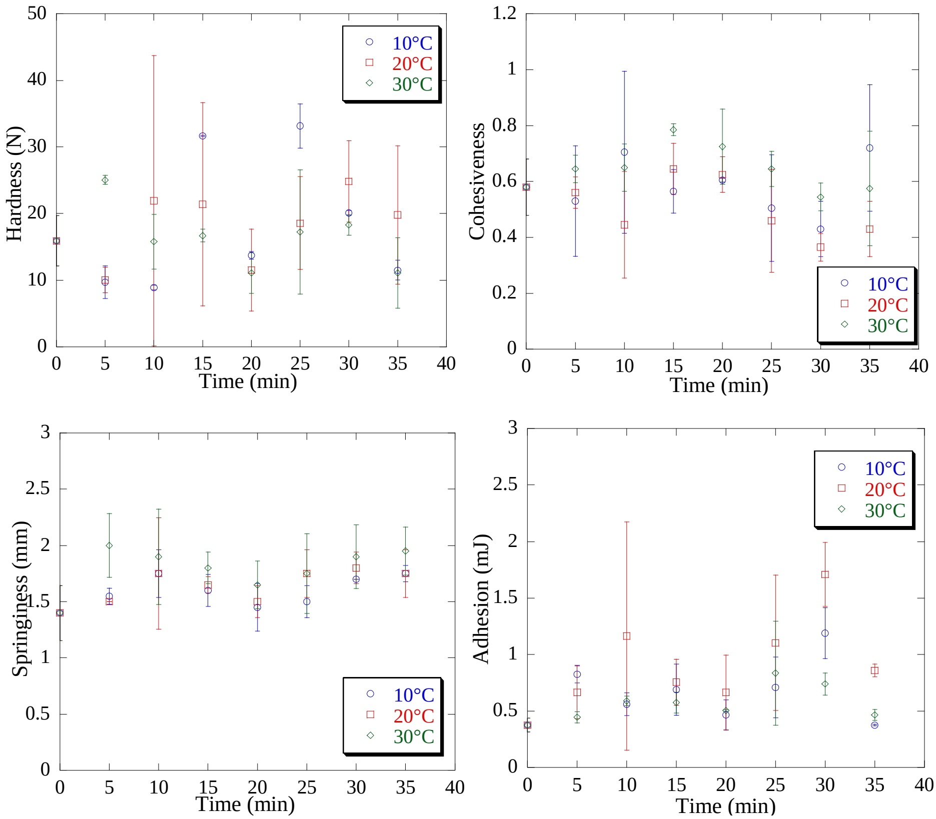

Fig.2 Textural properties during rehydration of freeze dried plum immersed in milk.

Springiness characteristics only showed significative differences at the ending of the rehydration in water at 20 °C, increasing from 1.5 to 2.25 mm. Slices of plum rehydrated in milk kept similar springiness than fresh ones. Adhesion characteristics had no significant differences in final values for both rehydration medias and rehydration temperatures.

3.2 Texture analysis of rehydrated hot air dried plums

Textural properties of hot air dried slices of plum during rehydration and its variation with respect time are presented in Fig. 3 and 4. Statistical analysis indicated that hardness of plum rehydrated in water (10 and 30 °C) had no changes compared to fresh product. Milk immersion allowed to reach similar values at 10 and 20 °C. Cohesiveness final values presented no significant differences for water rehydration of plum. Milk immersion presented only significative differences at 20 °C. With respect to springiness, final values after immersion in water showed differences at 30 °C. In contrast, milk rehydration at the three temperatures used, presented higher values that were significantly different from fresh plum. Finally, adhesion for plum rehydrated in water was similar to fresh one at 10 °C; milk immersion reached the same characteristics at 10 and 20 °C.

As can be seen, there were variations of texture properties during and at the ending of rehydration process, it can be attributed to the drying method used. According to Meda and Ratti [8], hot-air drying usually destroys the food thus, the final air dried products have a compact structure and a reduced volume, which can explain a non-uniform restoration of its original form, and as a consequence, variations during texture evaluation.

Assesment of texture profile of rehydrated plum slices allowed to see a clear influence of the drying methods. Freeze dried slices of plum presented less differences when compared to the fresh fruit. In contrast plums dehydrated by hot air, showed more variations on texture properties during rehydration. These differences were attributed to the tissue collapse and cell damage produced by higher air temperatures [11].

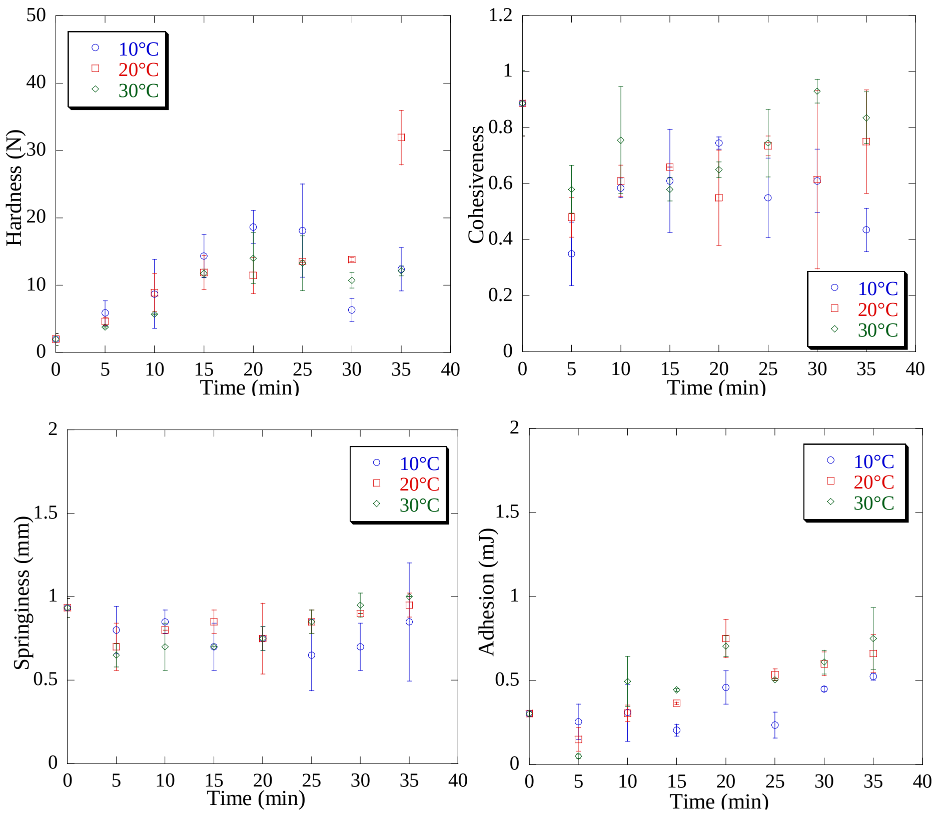

Fig.3 Textural properties during rehydration of hot air dried plums immersed in water.

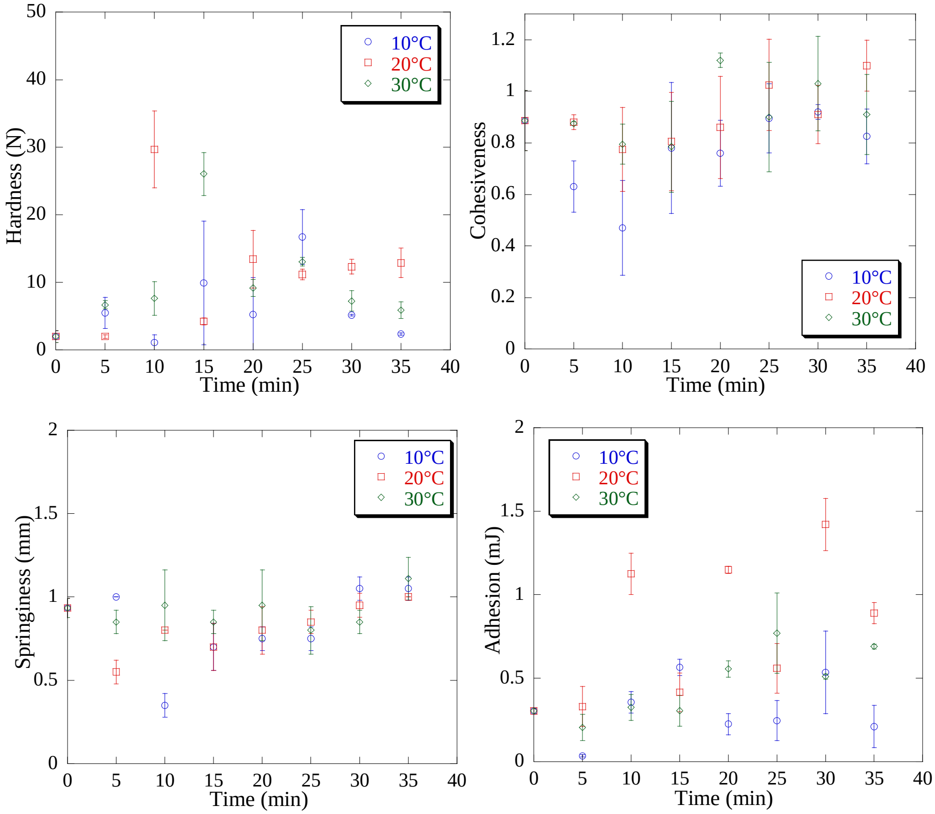

Fig.4 Textural properties during rehydration of hot air dried plums immersed in milk.

4. Conclusions

The texture studies were carried out on fresh, dehydrated and rehydrated plum slices, determining the parameters of hardness, cohesiveness, springiness and adhesion. Plum slices dehydrated by hot air presented more significative differences with respect to fresh plum that were attributed to the high temperatures during drying producing more structural damage as a consequence. On the other hand freeze drying allowed to reach texture characteristics close to fresh plum at the end of the most rehydration experiments. Finally it was possible to conclude that TPA provides valuable information not only after dehydration but also rehydration and application in freeze dried and hot air dried products, as plums, assures to the consumers a product with high quality and similar texture as fresh one, increasing its potential as snacks and cereal-based products.

5. References

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