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Comparative study of pear drying using solar stove and tunnel drying

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Abstract: Sun-dried pears of Portuguese variety S. Bartolomeu are relatively small fruits with peculiar organolephtic characteristics. The open sun drying has some disadvantages related with drying efficiency and food safety. However the drying with an economic and friendly energy source is an important characteristic of the drying methods and therefore several attempts have been made to develop processes using solar drying.

The present work studies two drying methods, namely solar stove and tunnel drying, with the advantages of using the solar energy and simultaneously reducing the exposure of fruits to contamination agents. Both processes were conducted in two consecutive years to analyse if the behaviour of each drying method shows evidence of a similar pattern.

The results enable us to conclude that the variation of normalized moisture of pears with the drying time follows a linear relationship in the solar stove while an exponential decay is observed in the tunnel drying. Despite the different climatic conditions, it is possible still to observe that the behavior of each process is quite similar in both consecutive years. However, in the second year the drying tends to be faster in both processes.

In addition, it is also possible to conclude that the total soluble solids/acidity ratio has a similar behavior along the drying in the two years for each process. However, the decrease in acidity of pears in the solar stove is more pronounced than the total soluble solids (TSS) and consequently a higher ratio of TSS/acidity is observed along the solar stove drying when compared with the tunnel drying.

Keywords: dried pear, TSS/Acidity, solar stove, tunnel drying.

Introduction

Drying of fruits is one of the oldest and cheapest forms of food preservation although their mechanisms are not entirely understood. The complex chemical and biological reactions that occur during the process with the consequent reduction in water activity will produce new products with peculiar nutritional and organoleptic characteristics. The regional sun dried pears of Portugal are a good example of a new product. This is a small sun-dried pear that is very appreciated in this country since with drying the astringency of fresh pears is lost and the fruit achieves a peculiar flavour, texture and flavour. Furthermore, they are also characterized by an intense reddish brown colour.

The traditional solar pear drying is described elsewhere (1) and the drying time is approximately 10-11days. There is a risk of deterioration due to dust and insect infestation. Although using the cheapest energy source this process is completely dependent on climatic conditions and there is still a lack of knowledge on the traditional sun-drying practice to allow a better process control and to maintain the dried pears characteristics over the years. In addition, the problems related with food safety and with the labour involved has been an incentive to use new processes to dry pears.

Solar crop drying has been demonstrated to be an effective alternative to traditional drying systems, especially in locations with good sunshine during harvest season (2). In fact, this method

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allows the production of dried fruits in less drying time and with higher food safety since the problems of hygiene are minimized.

The present work aimed to study the drying of pears in a solar stove and a tunnel drying as alternatives to the traditional air drying and compare the drying efficiency and the properties of the final product in two consecutive years.

The solar stove is a structure of aluminium completely enclosed in 3 mm greenhouse glass and with dimensions length=3.2 m, with=1.9 m, height=2m in the center and 1.3 at the sides. The system was equipped a hygrometer, to register the temperature and relative humidity at hourly intervals.

The tunnel drying has a net dimension of 40×60cm and is equipped with two trays of polyethylene and a balance to measure continuously the weight of the batch of pears. The air was heated by an efficient design of a low-cost solar collector and the temperature was controlled at 40 ºC and air velocity of 1.1 ms^{-1}.

Materials and Methods

In the first year (2007), the pears of the variety S. Bartolomeu were purchased in a farm and the fresh pears used in this study have the following properties: moisture (wet basis) = 76.2 %; acidity = 38.3 cm^3 NaOH/ 100 g dry solids; total soluble solids = 52.1 g/100 g dry solids and hardness = 84.3 N. In the second year (2008) the production of fruits in that farm was very poor, as it happens with this variety of pears, and therefore the fresh pears were purchased in another farm. The moisture (wet basis), acidity, total soluble solids and hardness are, respectively, 81 %, 20.9 cm^3 NaOH/100 g dry solids, 50.6 g/100 g dry solids and 74.1 N..

The pears were peeled and left to dry uncut inside a solar stove, over nylon nets, and over trays in the tunnel drying. Periodically two samples from each drying process were taken randomly to analyze their properties. The temperature of the system and moisture of pears inside both dryers were monitored during the drying. The process was finished when the final water content of the pears reached 20% approximately, since this is the value that allows good preservation characteristics. The dried pears were stored in plastic bags and refrigerated at 4 ºC.

Moisture content of the pear pulp was quantified with a Halogen Moisture Analyzer (Mettler Toledo HG53). Total soluble solids and acidity was estimated according to previous established methodologies (3). The hardness of the peeled fresh pears was determined by a presser tester with 8 mm of diameter. All the properties were determined in duplicate both to fresh and dried states.

Results and Discussion

The normalized drying curves (wet basis) of pears in the solar stove and tunnel drying processes are presented in Figure 1. A linear relationship was observed between the variation of moisture of the pears along the drying in a solar stove in the two consecutive years of drying. The slope of the straight lines is -0.004 and -0.005, respectively to the first and second years. Furthermore, the time to reach a final moisture content of 20% was about 147 hours for both years.

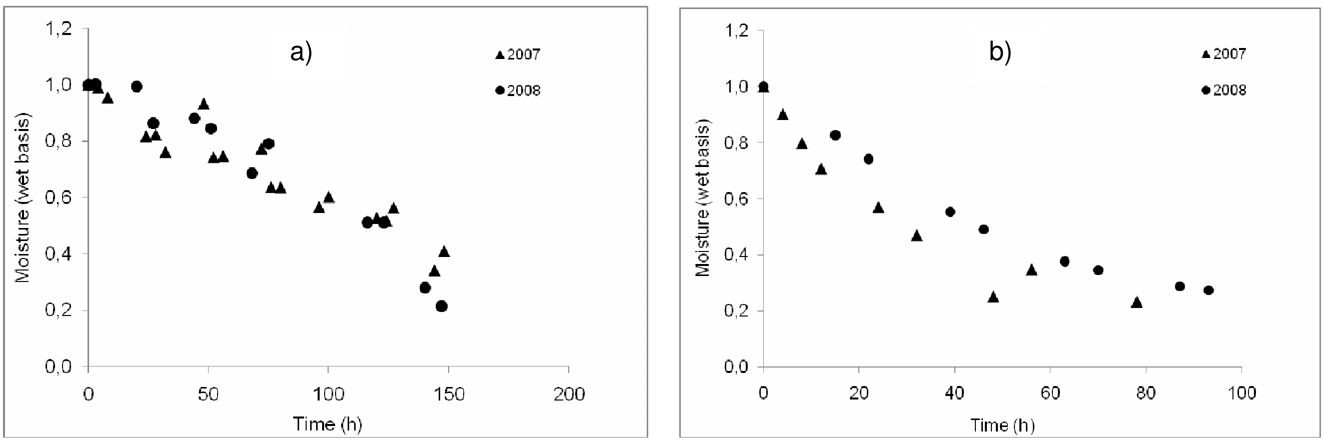

Figure 1 - Moisture profile of pears drying by solar stove (a) and tunnel drying (b) in two consecutive years.

The moisture of pears along drying in the tunnel drying follows an exponential decay and the drying time was found between 78 and 93 hours, respectively to the first and second year. The results for this drying process reveal a faster decrease in moisture and, consequently, a faster drying to reach the same final moisture content. This higher drying rate inside the tunnel is due to the fact that the air is heated by a solar collector and the temperature is controlled at 40 ºC inside the system. The pears dried in a solar stove received energy from incident radiation and, therefore, the temperatures of drying are dependent of the climatic conditions and of the hour of the day. Values of temperature inside the solar stove above 40 ºC are reached during a few hours of the day.

Regardless of the process, the acidity and the total soluble solids decrease along drying and the variation in the relation TSS/Acidity is shown in Figure 2 for both, the solar stove and the drying tunnel.

Comparing this ratio for the two dryings in the solar stove is possible to observe a similar behavior along time. Despite the dispersion of data obtained with the drying tunnel, the ratio also increases with drying time. However the decrease in acidity of the pears in the solar stove is more pronounced than the TSS and, consequently, a higher ratio of TSS/Acidity is observed along the solar stove drying as compared with the tunnel drying.

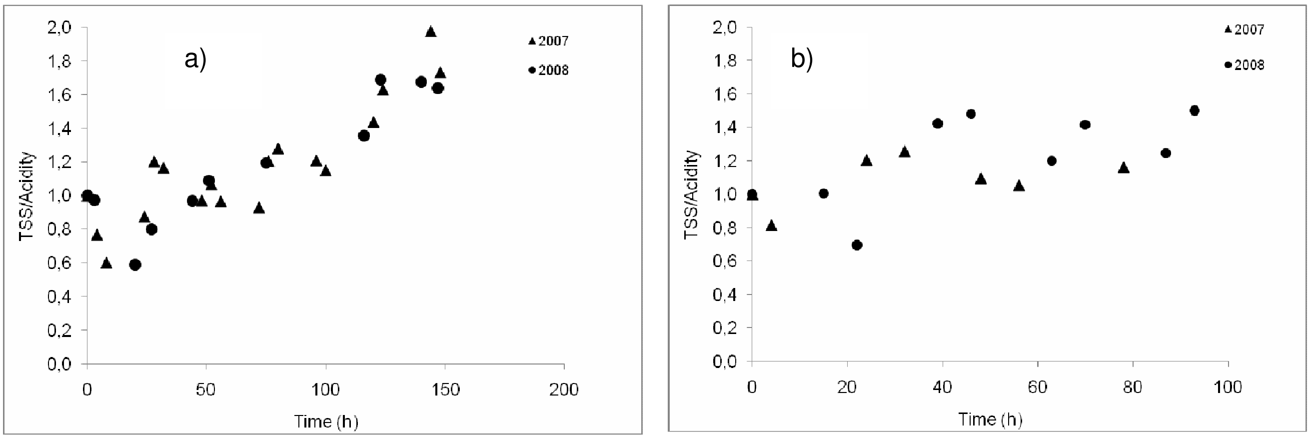

Figure 2 - Variation of the relation TSS/Acidity of pears along drying in solar stove (a) and tunnel drying (b) in two different years.

Conclusions

The present work studies two types of methods for drying pears, namely solar stove and tunnel drying, conducted in two consecutive years, in order to investigate if the behaviour of each drying method shows evidence of a similar pattern.

The results enable us to conclude that the variation of normalized moisture of pears with the drying time follows a linear relationship in the solar stove while an exponential decay is observed in the drying tunnel. Despite the different climatic conditions, it is possible still to observe that the behavior of each process is quite similar in both consecutive years. However, in the second year the drying tends to be faster in both processes.

In addition, it is also possible to conclude that the total soluble solids/acidity ratio has a similar behavior along drying in the two years for each process. However, the decrease in acidity of pears in the solar stove is more pronounced than the total soluble solids (TSS) and, consequently, a higher ratio of TSS/acidity is observed along the solar stove drying when compared with the tunnel drying.

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