THE CHERRY DRYING AS A COMPLEMENTARY CONSERVATION PROCESS TO CONSERVATION IN COLD

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Abstract: *Cherry is greatly enjoyed by consumers because of its excellent organoleptic and nutritional characteristics. This fruit is of the non-climacteric type, which forces its immediate commercialization after harvesting or else it should be properly conserved in cold. Every year there is a big waste of fresh cherry because he could not be marketed before deteriorating both in cooling chambers, or even in their own cherry trees due to a rapid ripening.*

In this project, the process of making cherry raisins is studied so as to provide increased use of fresh cherry. For that purpose, three different processes of dehydration of fresh cherry have been used, such as freeze drying, hot-air drying and solar drying. Three types of samples of pitted cherries were also used - natural cherry, blanching cherry and bleaching cherry with osmotic solution of fructose. In order to assess the performance of the dryers the curves of drying rate were determined and to assess the quality of the cherry raisins, fundamental parameters were determined, namely moisture content, water activity (aw), texture, total soluble solids and total acidity.

The results show that the drying rate of cherry samples is similar in the lyophilizer and hot air dryer, and yet faster in the latter. The dryer with lower rate drying and hence with higher drying time was the solar dryer. The characteristics of the cherry raisins depend on the type of dryer used and the pre-treatment used. The blanching pretreatment proved to be the most suitable. Regarding dryers, the solar dryer provided good quality cherry raisins, showing great potential at industrial level with the advantage of not consuming energy.

Keywords: Freeze drying, hot air drying, solar dryers, cherry raisins.

1. INTRODUCTION

Fresh cherry is a fruit with high nutritional value and excellent organoleptic characteristics and is therefore much appreciated by consumers [1]. Its excellent qualities nutritious, has provided increased production worldwide, having reached a value of 2,256,519 ton, in 2012 [2].
In Portugal, there has also been this evolution, obtaining a value of 10,577 ton in 2014, with the region of Beira Interior to stand out with 6634 ton (62.7%) [3].This fruit is highly perishable due to its high values of the water activity and moisture, which are between 0.99 and 0.98 and between 75 to 90%, respectively. Traditionally in order to increase time for commercialization their preservation is carried out in refrigeration chambers with a temperature and relative humidity between 0-1°C and 95-98%, respectively. Even in these conditions, its quality decreases rapidly forcing farmers to sell it quickly, before deterioration [4]. Furthermore, the fruit that ripens early in cherry trees, in times of increased production, it is not harvested and eventually it becomes a great economic waste. An alternative to reduce waste of this fruit and make new products available to consumers throughout the year, is to perform the dehydration and market it as cherry raisins. The main objective of this process is to reduce the moisture content of the product so that they become stable at room temperature. For that purpose, heat is used under controlled environment in order to remove most of the water present in the fruit by evaporation (or, in the case of freeze-drying by sublimation) [5]. However, the nutritional and sensory properties of dehydrated products depend on the mass and heat transfer conditions, these being affected by the temperature, air speed and drying method used [5]. To minimize the negative effects of this process on the quality of dehydrated products, the use of suitable dryers for the type of product and the use of pre-treatments such as blanching, osmotic dehydration, and the application of preservatives is recommended [6]. The aim of this study is to characterize the drying process of fresh pitted cherry, held in three types of dryers (freeze dryer, the solar and the hot air dryer) to obtain the cherry raisin. The evaluation of the performance of the dryers was carried out by reducing the moisture of the product during drying and through the physicochemical and nutritional analyzes of cherry raisins.

2. MATERIALS AND METHODS

2.1. Cherry samples

Fresh cherries used in this study *Prunus avium L.*, "De Saco" type variety were collected in July 2015, in a cherry orchard, located in the region of Beira Interior in central Portugal. Three kinds of samples with an a blanching mount of 2 kg of pitted cherries were prepared: fresh cherry (natural), blanching fresh cherry and blanching fresh cherry with osmotic solution of fructose. The sample of blanching fresh cherries was obtained by immersing the pitted cherries in a solution of 2 liters of water with 20 grams NaCl at 90 °C for 60 seconds. They were then removed and cooled under cold running water [7]. The sample of blanching fresh cherry with osmotic fructose solution was obtained by immersing the blanching cherries in an osmotic solution of fructose with a Brix of 40% for 14 hours at room temperature [7].

2.2. Cherry drying equipment

Three types of dryers were used: the lyophilizer, the hot air dryer and the solar dryer. The lyophilizer is a laboratory equipment Frezone 4.5 Labconco brand, comprising a vacuum chamber, a cooling system and a vacuum pump. The lyophilizer operated at a temperature and pressure within the vacuum chamber of about -46ºC and 0.120 mbar, respectively. A SANYO freezer was also used, with double compression state, to perform the ultra-rapid freezing of the sample cherries, up to a temperature of -82ºC. The hot

air dryer is of the semi-industrial type, and comprises a drying chamber with 0.44 m^3 in volume and 5 stainless steel trays spaced 10 cm apart. An electric resistance of 2000 W and a centrifugal fan installed inside provided heating and drying air movement inside the dryer. The fan is driven by an electric motor of 550 W. The drying air flows in the longitudinal direction, passing between the trays at a constant speed of 1 m/s. The temperature inside the drying chamber was controlled by a probe type K, and maintained constant, equal to 50°C. The inlet and the air outlet of the dryer was provided by two openings located on the right side, one on top of another, partially enabling recirculation of air from the interior to enhance its energy efficiency.
The solar dryer was built in wood and coated inside with an insulating material. It was divided into two sections connected together: a drying chamber with a length, width and height of 50, 50 and 70 cm, respectively, with 4 wire mesh trays close-knit, separated by a distance of 10 cm; and an insulated timber chamber with glass cover 30º and inclined to the ground. The outside air enters the chamber and is heated by means of solar radiation. Subsequently, the air naturally enters the chamber and moves upward, transversely to the trays and left on top of the dryer, by two opposing lateral openings with a width and height of 18 cm and 5 cm, respectively. Figure 1 shows the three dryers: the lyophilizer, the hot air dryer and the solar dryer.

Figure 1. Images of dryers: lyophilizer (left); hot air (center) and solar (right)

2.3. Methodologies and measurement equipment

To characterize the drying process of the cherry samples on the dryers, a number of standard cherries (n=30) were put on a net tray in the dryer and periodic weighing every 2 hours from the start to the end of drying was made. Simultaneously, the moisture content of the dehydrated cherries was also determined. Drying was terminated when the parameter values did not change after three consecutive weighing. Temperature, relative humidity and air velocity within the hot air dryer and lyophilizer and the solar dryer outside air were also determined using a multifunction machine of the Testo 435-2 brand with a probe 3 functions and 6 data-loggers Lascar brand.
For physicochemical characterization of fresh cherries and cherry raisins a set of parameters was used whose average value was obtained through the results of testing to an amount of 24 cherries. Weight was measured with analytical scales of Sartorius brand with a precision 0,01g; the gauge was determined with a digital caliper; the moisture was achieved using UV OHAUS brand scales with an accuracy of 0,001 g; water activity (aw) was measured with a device of "Rotronic" brand through the electronic

hygrometer method; the color parameters were measured through the colorimeter CR400 brand "Konica Minolta". Reading was carried out in two distinct points in each of the cherries and 24 using the color system L*, a* and b* (CIELAB); the texture was determined using a texturometer TA.XT Plus, Stable Micro Systems brand; total acidity (mEq./100g) was obtained in Automatic Titrator TitroMatic 2S + 2B Crison brand and the total soluble solids (Brix) were obtained by direct reading of a digital refractometer of ATAGO brand.

3. RESULTS AND DISCUSSION

Table 1 presents the physicochemical characteristics of fresh cherries used in the three types of samples in this study.

Table 1. Characteristics of the sample fresh cherry

Characteristics			Average values
Average weight		(g)	7.73 ± 1.73
Medium calibre		(mm)	18 ± 3
Moisture		(%)	72.42
Water activity (aw)			0.986
ºBrix			21.3
Color	L*		20.11
	a*		20.07
	b*		6.14
Texture		(N)	190.7
Total acidity		(mEq/100g)	11.77
pH			3.90

The physicochemical characteristics of this type of cultivar are close to those recorded for other cultivars [8]. In the results, high moisture content values (72.42%) and water activity (0.986) stand out. In order to evaluate the performance of dryers, the drying rate of the product, DR was considered, given by the following expression:

$$DR = \frac{Mt - Mf}{M0 - Mf} \qquad (1)$$

In which DR is the dimensionless velocity or rate of drying, Mt is the weight of the product along the drying time (kg); Mf is the weight of the product at the end of drying (kg) and M0 is the initial weight of undried product (kg) [9]. These values were obtained by weighing the amount of standard cherries placed inside the dryers. Figure 2 graphically presents the drying rate, DR, natural dehydration of the sample on the lyophilizer and the cherry hot air dryer. As this sample could not complete dehydration in the solar dryer, it not represented with a drying curve. The process was discontinued on the third day of drying because cherry moisture could not be decreased under 51.39% and due to the onset of deterioration of the cherries with the appearance of mold. Low air velocity in the dryer, which was 0.05 m/s contributed to this degradation. The reduced air velocity, does not favor entrainment of moisture from the natural cherries, keeping high values of the water activity in an environment where temperatures were high, leading to deterioration. Figure 2 shows that the hot air dryer has a higher drying speed of fresh cherry, taking 36 hours whereas lyophilizer took 52 hours. From the analysis of the curves in drying rate, DR, the existence of a first phase of faster drying process until the start of next 24 hours is observed, followed by a second, slower phase, until the end of drying.

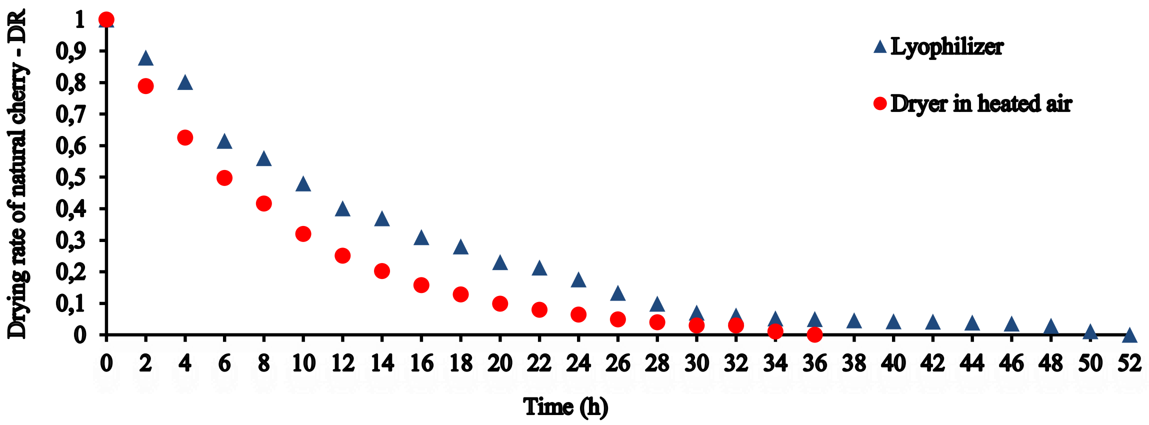

Figure 2. Drying rate curves of sample natural cherry

Figures 3 and 4 show drying rate curves of the blanching cherries and blanching cherries with osmotic solution and fructose, respectively. The two graphs analysis show that dehydration of these two samples was possible in the three types of dryers, in which the effect of pretreatments influenced the vaporization of water Cherries. It also shows that the drying rate, DR, registered in the dehydration of these two samples of cherries, have similar profiles in the three types of dryers. However, dehydration of two samples carried out in the lyophilizer and hot air drier have a very similar drying time (30 hours), and it is the hot air drier which records a higher drying rate, DR, in first drying stage. Regarding the solar dryer, the curves of the drying rate, DR, shown in Figures 3 and 4, were constructed using the values obtained with the above-dryer to solar radiation (day) and no exposure to sunlight (night), that is, points corresponding to daily periods of sun exposure (1st day: 0-8 hours; 2nd day: 24-32 hours; 3rd day: 48-56 hours; 4th day: 72-78 hours and 5th day: 96-100 hours) and points corresponding to the remaining time, with the dryer installed inside the Agrifood Technological Center.

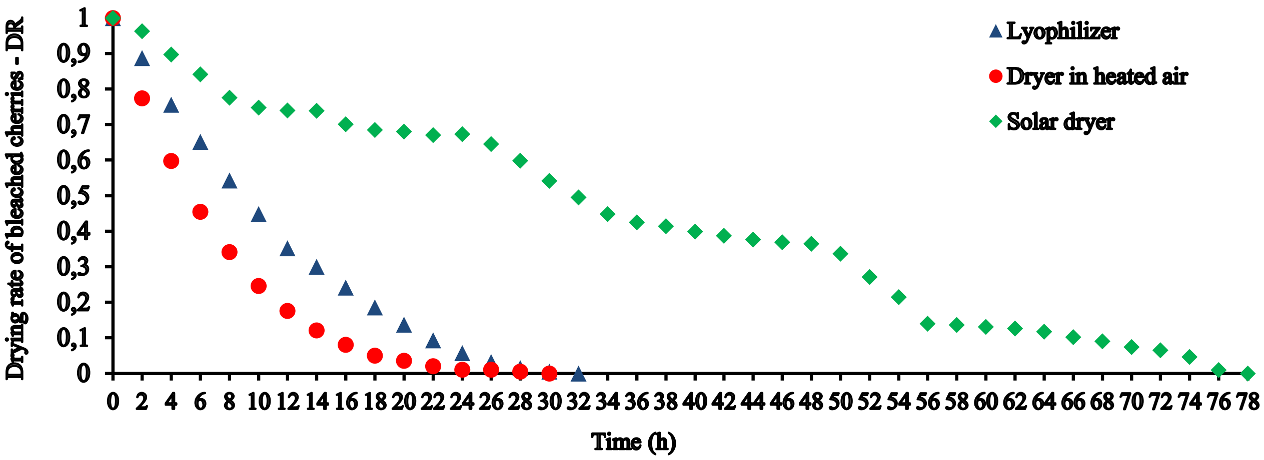

Figure 3. Drying rate curves of the cherry sample with blanching

From the results analysis, it appears that the decrease in moisture was very slow taking 4 days to dry cherry with bleach (see Figure 3) and 5 days to dry cherry with blanching osmotic solution of fructose (Figure 4). The results show that higher drying rate, DR, is recorded in the periods of sun exposure and the effect of pre-treatment has a great influence in the dehydration process in the solar dryer, as the drying rate, referring to cherry dehydration with blanching is higher compared to the level for dehydration cherry sample with blanching and osmotic solution fructose, filed drying times of 78 and 100 hours, respectively.

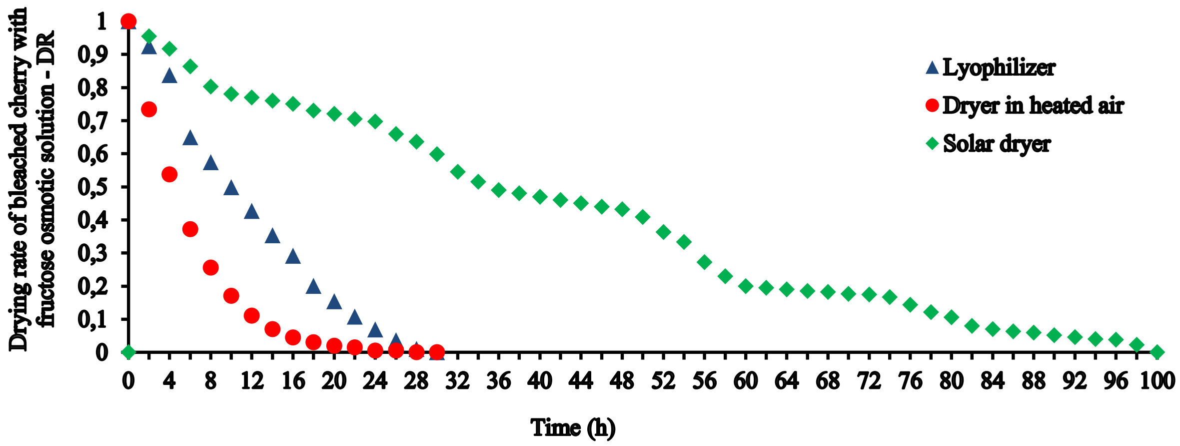

Figure 4. Drying rate curves of cherry samples blanching and submitted to osmotic solution of fructose

The results show that the hot air dryer is the one with the highest drying rates for the three cherry samples, and so, is the one that takes the less time to obtain cherry raisins. However, unlike the solar dryer, both hot air dryer and lyophilizer have an energy cost associated with its operation. The results of physicochemical analyzes of cherry raisins have a mean moisture content (%) ranging from 9.5 to 12.1, the water activity (aw) from 0.54 to 0.66 and the total acidity (mEq./100g) and between 2.49 and 4.43 pH between 3.8 and 4.1. Regarding color, the results obtained for the L* parameter shows that the values are between 17.65 and 23.24. The cherry raisins obtained by solar dryers have a darker shade and are the ones with better visual appearance.

4. CONCLUSIONS

In this study the analysis of the dehydration of natural cherries, blanching cherries and blanching cherries with an osmotic solution fructose was carried out in a freeze drier, a hot air dryer and solar dryer. The drying of cherries speeds are very similar to processes performed on the lyophilizer and hot air, the latter being where the drying is faster, i.e., where the drying time is shorter. The solar dryer is the one that it takes the greatest of drying time but with the advantage of being the one that has no energy costs. The quality of the cherry samples from three types of dryers is identical and present values of the moisture and water activity within the recommended limits in order to remain stable. The pretreatments have a slight influence on the drying rate and some physicochemical parameters of cherry raisins. Taking into account the overall analysis of all parameters, and visual observation, it is concluded that the cherry raisins obtained by the solar dryer are those with the best visual aspect, with a dark tint and typical texture of raisins, so, taking into account that this dryer does not consume energy, it has great potential for the manufacture of cherry raisins at industrial level.

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