SOUR CHERRIES HOT AIR DEHYDRATION

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Abstract
Nowadays, there is an increasing interest in the consumption of fruits in the human diet. Many studies show that their large variety and their composition have an important role in the protection against degenerative diseases such as cancer, heart diseases, brain dysfunctions, cataracts etc.
Rich in water, sugars, vitamins, mineral salts, sour cherries are counted among the most appreciated fruits. Their seasonal nature and their short life prompt the use of technological procedures to make them available all year round. Besides a weight and volume reduction in order to decrease transport and storage costs, dehydration offers a mean of preserving fruits in a stable and safe condition providing a shelf life longer than that of fresh products.
The aim of this study was to identify the drying kinetics of dehydrated sour cherries as well as the effect of the hot air drying procedure on the total acidity and on the ascorbic acid content.

Keywords: sour cherries, moisture content, dehydration, drying velocity, total acidity, ascorbic acid

1. INTRODUCTION

Sour cherries (*Prunus cerasus* L.) occupy the *Cerasus* subgenus within *Prunus*, being fairly distinct from plums, apricots, peaches and almonds. They are members of the *Rosaceae* family, and subfamily *Prunoideae*. Sour cherries are relatively diverse and broadly distributed around the world, being found in Asia, Europe and North America [1]. About more than 65,000 t of sour cherries were obtained in 2008 in Romania. 74% of the total quantity is consumed in fresh state while 26% are generally used for processing purposes [2].
Drying is used to preserve and store fruits for longer periods by removing some of their moisture content to the level at which microbial spoilage and deterioration reactions are greatly minimized [1]. In addition, commercial interest on dried fruits has been increasing. Improper drying causes considerable damage and waste of seasonal fruits [3].
In recent years, much attention has been paid to the quality of foods during drying. Both the method of drying and physicochemical changes that occur in tissues during drying affects the quality of the dehydrated product. More specifically, the method used for drying affects properties such as color, texture, density, porosity or chemical composition [4].
Recently, many studies have appeared in the literature on the investigation of drying behavior of different fruits. Kiranoudis et al. [5] studied the influence of temperature on the drying kinetics with hot air-drying of some fruits (namely, apple, pear, kiwi and banana) and determined the equilibrium moisture content of these fruits. Increasing the drying air temperature decreased the equilibrium moisture content and the total drying time. Nogueira-Terrones et al. [6] evaluated the drying process of nejayote using a hot air cabinet dryer and analyzed the sorption isotherms of the product. Kashaninejad M. et al. [7] determined the effects of drying air temperature on the drying kinetics of Purslane using an air recirculating dryer. As expected, drying time decreased and drying rate increased with increasing drying temperature. Kaya et al. determined the effects of drying air temperature, air flow rate and air relative humidity on the drying kinetics of quince [8], apple [9] and pumpkin [10] using a convective dryer. Increasing the temperature or velocity of the drying air decreased the total drying time, while decreasing the relative humidity prolonged it. Maskan [11] realised a comparison of the microwave, hot air and hot air–microwave drying methods for the processing of kiwifruits in respect to drying, shrinkage and rehydration characteristics

obtained by the three drying techniques. Drying with microwave energy or assisting hot air-drying with microwave energy resulted in increased drying rates and substantial shortening of the drying time. Erenturk et al. [12] investigated the degradation kinetics of vitamin C for whole rosehip drying using a laboratory dryer at various temperatures. Moisture content of solid also decreased with increasing temperature. Degradation of vitamin C increased with raising drying air temperature. Qing-guo et al. [13] determined the quality parameters, such as vitamin C and chlorophyll contents, shrinkage, rehydration capacity, colour, texture, and microstructure changes of edamames dried by a convective drying, vacuum microwave drying, convective-vacuum microwave drying, and freeze drying, and the differences among the methods were compared and discussed. Goula and Adamopoulos [14] determined a mathematical model for the reaction kinetics of ascorbic acid degradation to describe the rate of vitamin C loss in a drying process of tomato halves with hot air. Degradation of vitamin C increased with raising drying air temperature.

This work studied the behaviour of sour cherries when submitted to convective air drying. More specifically, the study is focused on the following purposes:

- investigation of the drying kinetics for various conditions;
- investigation of the influence of drying parameters on the total acidity and on the degradation kinetics of ascorbic acid.

2. MATERIALS AND METHODS

2. 1. Sample Preparation

Ripe sour cherries (*Prunus cerasus* L.) of proper maturity, uniform size, red color and firm texture were procured from a local market. The over-ripe and bruised fruits were separated manually. After washing in cold water to remove all foreign material such as dust, dirt and leaves the fruits were cut into halves. The sample weight was recorded using an analytical balance (analytical grade accuracy ± 0.0001 g). Samples of about 40 g were used for each experiment.

2. 2. Drying Procedure

Drying experiments were carried out using a laboratory oven (Memmert, Germany) for 15, 30, 45, 60, 75 and 90 minutes at four different air temperatures (60, 80, 100 and 120°C). Prior to conducting the drying procedure the equipment was run for half on hour to achieve steady-state conditions for the desired temperature levels of the drying air.

2. 3. Chemical Analysis

Fresh and dried sour cherries were evaluated for various chemical parameters.

The moisture content was determined by the oven drying method using the relation 1:

$$\text{Moisture content (\%)} = \frac{m_2}{m_1} \cdot 100 \qquad (1)$$

where:
m_1 – fresh fruits mass, g
m_2 – dried fruits mass, g

The drying velocity was determined based on the experimental results and defined as the evolution of moisture content in time (eq. 2):

$$\text{Drying velocity (g/s)} = \frac{\Delta m}{\Delta t} \qquad (2)$$

where:
Δm – mass variation, g
$\Delta m = m_2 - m_1$
m_1 – mass of fresh fruits, g
m_2 – mass of dried fruits, g
$\Delta t = t_2 - t_1$
t_1 – initial time, s
t_2 – final time, s

Titratable acidity was determined by extracting 10 g of sour cherries in 60 mL of distilled water at 60°C. The extract was made to 100 mL with distilled water and 20 mL of the filtered extract were titrated against 0.1 N sodium hydroxide solution in presence of phenolphtaleine. Total acidity was found using the relation 3:

$$\text{Total acidity (\%)} = \frac{100 \cdot V \cdot V_1 \cdot K}{M \cdot V_2} \quad (3)$$

where:
V – sodium hydroxide volume 0.1 N used for titration, mL
V_1 – total volume solution, mL
V_2 – volume of the extract analysed, mL
M – sour cherries mass, g
K – malic acid quantity coresponding to 1 mL of sodium hydroxide 0,1 N
K = 0.0067 g

For determination of sour cherries ascorbic acid amount, 10 g of sample were grinded in presence of hydrocloric acid. The resulted mixture was made to 100 mL with distilled water. 10 mL of the filtered extract were homogenised with 30 mL of distiled water, 5 mL of potassium iodide 1% and 1 mL of starch solution 1% and titrated against potassium iodate 0.004 N. The blue-black color is the endpoint of the titration.
The amount of ascorbic acid was established using the fallowing relation:

$$\text{Ascorbic acid (mg/100 g)} = \frac{100 \cdot t \cdot V \cdot d}{M} \quad (4)$$

where:
t – potassium iodate titre reported to the ascorbic acid

$$t_{KIO_3/ascorbic\,acid} = \frac{c \cdot E}{1000}$$

where:
c – potassium iodate concentration
c = 0.004 N
E – ascorbic acid equivalent, g
E = 88 g

$$t_{KIO_3/ascorbic\,acid} = \frac{0.004 \cdot 88}{1000} = 0.352\, mg/mL$$

V – volume of potassium iodate 0.004 N used for titration, mL
d – dillution
M – mass of the sample analyzed, g
The results showed initial moisture content of about 86.13 % (w.b.), a total acidity of 1.18% and an amount of 5.7 mg/100 g of ascorbic acid.
At the end of each drying experiment, the final moisture content, the total acidity and the amount of ascorbic acid of the samples were determined.

3. RESULTS AND DISCUSION

3. 1. Moisture Content

Two periods can be distinguished in a drying process: one called constant drying rate period and other called the falling drying rate period. During the first period the rate of moisture removal is mainly dependent on the surrounding conditions and only affected slightly by the nature of the product. The end of this period is marked by a decrease in the rate of moisture migration from within the product below that sufficient to replenish the moisture being evaporated from surface. The falling drying rate period is dependent essentially on the rate of diffusion of moisture from within the product to the surface and also on moisture removal from the surface. Both the external factors and the internal mechanisms controlling the drying rate regimes are important in determining the overall drying rate of products. Generally for food (including fruits) the constant drying rate period is not observed [15, 16].
The moisture content of the dried sour cherries as a function of drying time is presented in Figure 1 for 60, 80, 100 and 120°C and for 15, 30, 45, 60, 75 and 90 minutes of drying respectively. As expected, temperature has an important role in the drying process. A higher temperature decreased the drying time. After 90 minutes of drying at 60°C only 27.28% of moisture content was removed. The same quantity of water is evaporated in 30 minutes at

80°C and in less than 15 minutes if the drying temperature is setup at 120°C.

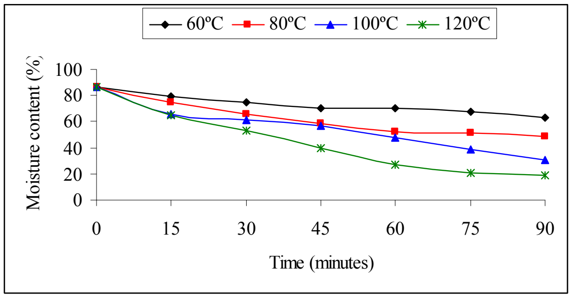

Figure 1. Moisture content as function of drying time for different temperatures

Variation of the drying velocity with the drying time is shown in Figure 2. The study of the resulted curves indicates only the presence of the first drying period which supports the theoretical and practical notions concerning food drying but the absence of the drying period at constant speed may also be caused by the short drying time used. The general profile of these curves is similar for the experiments conducted at 60 and at 80°C. A temperature of 120°C reduced three times.

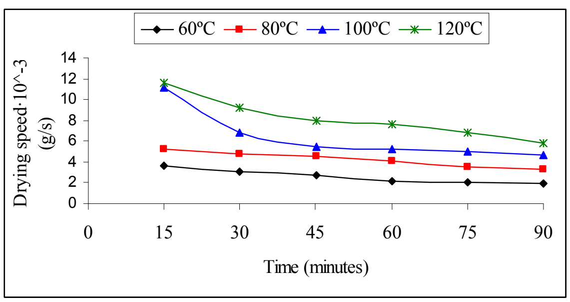

Figure 2. Evolution of drying speed in time

3. 2. Total acidity

In free state or as different salts (particularly as potassium salts) the organic acids are among the most important components of fruits being considered having an important roll in organoleptic fruits qualities. Their amount varies between 0.1 and 7%, the most common being mallic acid, citric acid and tartaric acid. In sour cherries the main acid is malic acid followed by the salicylic acid.

Heat treatments in the dry oven applied to sour cherries modified drastically the titratable acidity (Figure 3). The augmentation of drying air temperature conducted to an increasing of the fruits acidity due to the water evaporation and to the product concentration. While using low drying temperatures (60, 80°C) did not strongly modify the acidity of the dried products compare to that of the fresh fruits at 120°C the total acidity increased three times after 75 minutes of drying.

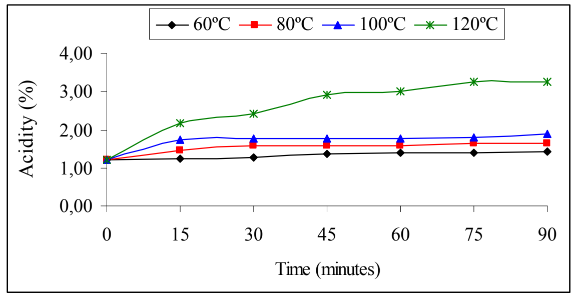

Figure 3. Influence of drying conditions on the dried sour cherries total acidity

3. 3. Ascorbic Acid Content

Generally, the quality of a foodstuff is determined by its contents of vitamins, minerals and calorific values that can be affected by drying process conditions and moisture contents. Some vitamins are quite important in human health. For instance, vitamin C is one of the major non-enzymatic antioxidants in the body. It has a protective effect against lung, bladder and prostate cancers [17].

As shown in Figure 4, the degradation of vitamin C is negatively affected by the drying conditions. Loss of ascorbic acid following heat treatments has been widely reported [12, 18-21].

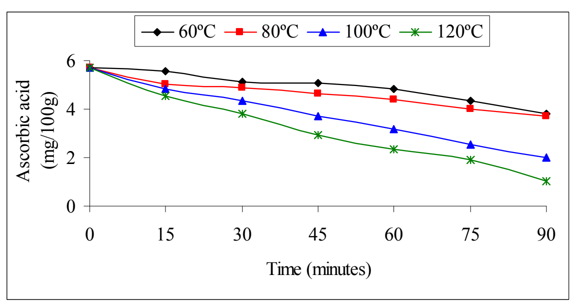

Figure 4. Changes of sour cherries ascorbic acid amount during drying process

The amount of ascorbic acid in dried cherries is influenced by the drying temperature and the duration of the process. Increasing temperature increased the degradation of vitamin C in the product. The total losses were estimated at 33.59% at 60°C, at 35.27% at 80°C, at 64.95% at 100°C and at 82.04% when the temperature used was 120°C and are due to the ascorbic acid oxidation phenomena during drying. Oxidation reaction is favored by heat. For this reason higher drying temperatures alter much more the vitamin C.

4. CONCLUSION

The drying kinetics of sour cherries was investigated as a function of drying conditions. Experiments were carried out at different air temperatures for different periods. Increasing the air temperature and the duration of process increased the total acidity of the dried fruits and conducted to an important degradation of the amount of ascorbic acid.

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