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Original scientific paper

EFFECT OF DRYING IN THE PRESERVATION OF APPLE AND ITS VITAMIN C CONTENT

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Abstract

Drying is a widely used food preservation process in which water removal minimizes many of the moisture-driven deterioration reactions impacting the product quality. The aim of this research was to analyze the effect of drying in the total number of microorganisms and vitamin C content of *golden delicious* apple fruit. In this research ascorbic acid solution was applied as a pretreatment procedure for 10 minutes. Drying was performed at 60 °C for 10 hours using a drying oven. The parameters were determined before and after the drying procedure, except vitamin C content which was determined also after the pretreatment with ascorbic acid solution. Total number of microorganisms from 11 x 10^3 CFU/ml decreased to no growth after the drying procedure which came as a result of the reduced moisture in the apple slices, the reduction of moisture was confirmed by the determination of the moisture content of the dried fruit which was 22.93 %. Vitamin C content slightly increased from 41.5 mg/100ml in the fresh fruit to 46.5 mg/100ml in the pretreated apple fruit with ascorbic acid solution, whereas in the dried fruit the vitamin C content decreased to 13.25 mg/100g due to long exposure to high temperatures. The reduced moisture content in the apple fruit decreased the total number of microorganisms but on the other hand the drying temperature and the long exposure to that temperature decreased the vitamin C content.

Keywords: apple, drying, vitamin C, microorganism, preservation

1. Introduction

Consumers have been encouraged to increase their daily intake of fruits and vegetables since their nutritional value as suppliers of vitamins and minerals is recognized. However, the water content of most of fruits and vegetables is higher than 80%, which limits their shelf-life and makes them more susceptible to storage and transport conditions. Consequently, an expansion in the production and consumption of processed foods has been verified. Among them, dehydrated fruits and vegetables attract attention because they can be easily produced, can be stored and transported at relatively low cost, and have a reduced packing cost **Invalid source specified.**.

The main feature of drying consists of decreasing the water content of fruits and vegetables in order to avoid or slow down the spoilage by microorganism. Drying is also a way of preserving seasonal fruits and vegetables for later use **Invalid source specified.**. Drying also slows down the action of enzymes (naturally occurring substances which cause foods to ripen), but does not inactivate them.

Drying of foods, including fruits and vegetables, has been widely used for removing and lowering water activity to reduce the risk of microbial development and to decrease enzymatic reactions and chemical degradations. The drying process allows flexibility in availability of these products

regardless of season. Therefore today, the dehydrated food industry occupies an important place within general food industries throughout the world **Invalid source specified.**.
Consumption of dried apples has been increasing recently, and dried apples are part of numerous prepared foods including snack preparations, breakfast foods and others **Invalid source specified.Invalid source specified.**.
Due to the characteristics of conventional drying processes, nutrients sensible to heat, light, and oxygen are degraded during the process. Vitamin C is an essential substance found mainly in fruits and vegetables. This nutrient not only prevents diseases like scurvy but also plays the role of biological antioxidant. The vitamin C can be easily degraded, depending on many variables such as pH, temperature, light, and presence of enzymes, oxygen, and metallic catalyzers. Due to the importance of vitamin C for human nutrition as well as its use as a quality indicator for food processes, this study aims to present the effect of drying processes of apple fruit to vitamin C content **Invalid source specified.**.

2. Material and methods

The variety of apples used for this study was Golden Delicious taken in the local markets of Gostivar, North Macedonia. The analyses were conducted in the laboratories of the Faculty of Food Technology and Nutrition, University of Tetova. First the apples were dried where some prior procedures were taken such as: washing the apples, cutting them into slices and then pre-treating them with vitamin C solution. After the pre-treatment the apples were dried in a drying oven in 60 °C until the drying was finished **Invalid source specified.**. In the fresh apple were conducted these analysis: vitamin C content and total number of microorganisms, in the pretreated apple was conducted the vitamin C content and in the dried fruit: moisture/dry matter content, vitamin C content and total number of microorganisms.
For each parameter were analyzed two samples of the apple for an average value.
Determination of moisture content/dry matter was done by AOAC Official Method 934.06, were the samples were dried in drying oven at 70 °C until consecutive weightings made at 2 h intervals varied by less than 3 mg.
Determination of vitamin C content was done by the iodine titration method, in the presence of starch solution as an indicator.
Determination of total number of microorganisms was done by the horizontal method for the enumeration of microorganisms with surface plating technique EN ISO 4833-2:2013.

3. Results and discussion

The results presented in Table 1 show the values of the chemical analysis of the apple slices, but each one of them will be discussed further.

Table 1. Results of the chemical analysis

Sample	Moisture content - %	Dry matter - %	Vitamin C content in the fresh fruit - mg/100ml	Vitamin C content in the pre-treated fruit - mg/100ml	Vitamin C content in the dried fruit - mg/100g
1	22.82	77.18	41	47	13.6
2	23.04	76.96	42	46	12.9
Average value (stdev**)**	**22.93 ±0.15**	**77.07±0.15**	**41.5±0.70**	**46.5±0.70**	**13.25±0.49**

Moisture/ dry matter content

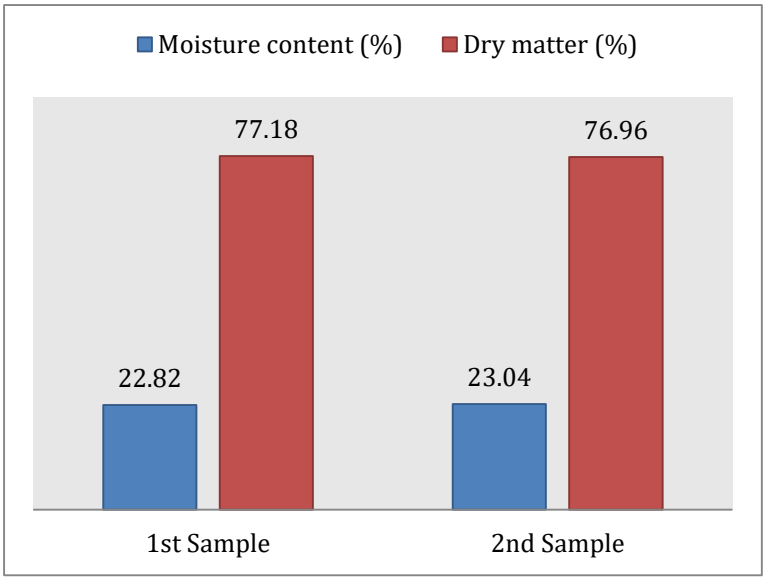

Figure 1. Dry matter and moisture content of the apple slices after drying

Dry matter content and moisture content of the apple slices are presented in table 1 and figure 1 , where the average result for moisture content is 22.93%±0.15 whereas for dry matter content is 77.07%±0.15.

The studies from other authors **Invalid source specified.** show a higher content of dry matter or total solids in their analysis which can differentiate because of the different conditions of the drying process. The value of the moisture content in the dried fruit is in accordance with the UNECE standard concerning the marketing and commercial quality control of dried apples**Invalid source specified.**.

Vitamin C content

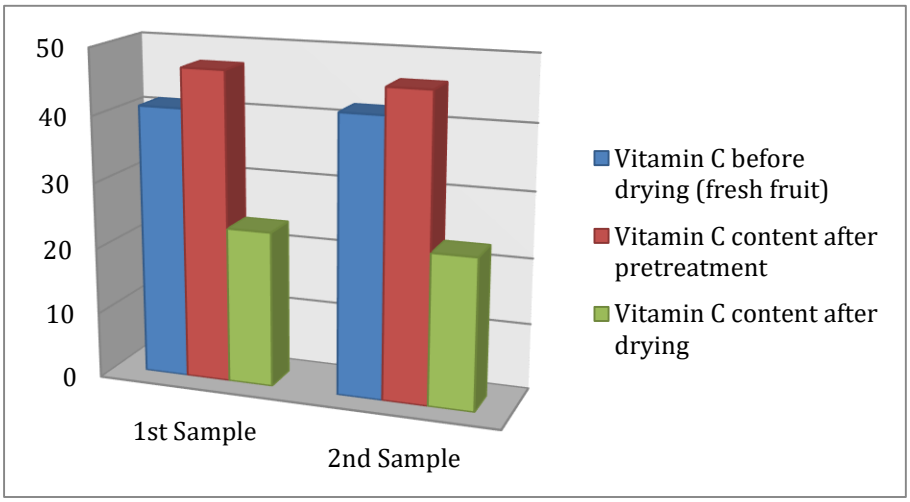

Figure 2. Content of vitamin C before drying, after pretreatment and after drying

The results for vitamin C content are presented in figure 2, where we can see a range of values from 12.9 mg/100g to 47 mg/100ml. In the fresh fruit the content of vitamin C was 41.5 mg/100ml ±0.70, in the fruit after pretreatment with ascorbic acid solution was 46.5 mg/100ml ±0.70 and in the dried apple fruit was 23.25 mg/100g ±0.49.

Higher content of vitamin C (46.5±0.70) was found in apples after pretreatment compared to the vitamin C content of the fruits after drying (13.25±0.49), this due to irreversible oxidization of vitamin C during drying. Also, the difference in values is expected, taking into account the sensitivity of the vitamin C to the external conditions (temperature, light, air), that leads to certain losses, as well as the various climatic conditions, agro technical measures, etc. **Invalid source specified.**.

The results obtained as shown in figure 2 show us that the values are comparable to the results of other studies conducted on the evaluation of vitamin C **Invalid source specified.**.

Total number of microorganisms in the apple fruit before and after the drying process

The total number of microorganisms was determined in apples before treatments and in apple slices after drying.

Both apple samples (before drying and after drying) were diluted to -4 or 1:10 000 and incubated at 30°C for 72 hours in PCA (plate count agar). After incubation, the colonies were counted and the total number was calculated.

Table 2. Number of colonies in Petri dishes - Fresh apples

Dilution	Colony
-1	98
-2	14
-3	1
-4	0

There was no growth of microorganisms in the dried apple samples whereas in the fresh apples referring to the Table 2 the total number of microorganisms was 11 x 10^3 CFU/ml.
The results obtained as shown in Table 2 show us that the values are comparable to the results of other studies conducted on the evaluation of total number of microorganisms **Invalid source specified.**.

4. Conclusion

Based on the moisture content of the dried apple fruit (22.93%) which value was according to the UNECE standard concerning the marketing and commercial quality control of dried apples, the drying process was done properly. From the obtained results the vitamin C content, both in the fresh apple fruit and the pretreated apple had a higher content (41.5 and 46.6 mg/100ml respectively), while in dried apple fruit this content decreased (13.25 mg/100g). The vitamin C can be easily degraded, depending on many variables such as pH, temperature, light, and presence of enzymes, oxygen, and metallic catalyzers. As the main factor here we had the high temperature and long exposure of apple fruit to this temperature.
By analyzing the total number or microorganisms in the fresh apple fruit and in the dried fruit we confirm the effect of drying in the number of microorganisms, which from 11 x 10^3 CFU/ml reached no growth in the dried fruit.

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