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THE EFFECTS OF DRYING ON ROMANIAN COMMERCIAL MUSHROOMS

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Abstract

The aim of our study was to determine the variation of some physicochemical parameters for two mushroom species that were air-dried at various drying times. The sensorial attributes of dried mushrooms were analyzed. The macronutrients determined are reducing sugars and total protein. It was found that after 12 hours of drying, there was a loss of moisture of 84 % for Agaricus and 92 % for Pleurotus. The Agaricus and Pleurotus mushrooms presented a reduced amount of proteins and reducing sugars at drying. After 12 hours of drying there was a reduction in the content of reducing sugars by 8 % for Agaricus and by 13 % for Pleurotus. The total protein content was decreased after 12 hours of drying with 7.5 % for Agaricus and with 13.5 % for Pleurotus. Two hydrosoluble vitamins were determined: ascorbic acid and niacin. The niacin proved to be more stable at drying than the ascorbic acid. After 12 hours of drying the ascorbic acid amount in Agaricus decreased by 5 % and in Pleurotus by 10.6 %, and after 48 hours of drying it decreased by 40.4 % in Agaricus and by 39 % in Pleurotus. The amounts of chemical and biochemical parameters were lower after 48 hours of drying than after 12 hours of drying. Compared with the fresh mushrooms, all the sensorial attributes decreased with one or two points after 12 hours of drying.

Keywords: Agaricus bisporus, ascorbic acid, niacin, Pleurotus ostreatus, preservation.

1. INTRODUCTION

Pleurotus ostreatus and *Agaricus bisporus* are two of the most commercialized mushroom species on the Romanian markets. Fresh mushrooms have a high amount of proteins and vitamins compared with other vegetables. Also, they are very perishable foods because they have a high amount of moisture: 85 to 95 % wet basis (Arora *et al*., 2003).

Drying, canning and freezing are the most suitable methods for long-term mushroom preservation. Drying is a much cheaper method as compared with other thermal preservation methods (Walde *et al*., 2006). Therefore the use of dried mushrooms is a commercial practice and its applications in the food industry are multiple.

Even if mushrooms have a high amount of water, they can be preserved by drying. The methods used for drying can be either conventional, like convective hot-air drying (Giri *et al*., 2007), or accelerated, like microwave-vacuum drying or ultrasonic drying (Giri *et al*., 2007; Jambrak *et al*., 2007).

In the case of hot-air drying for commercial purposes, the temperatures vary between 50 and 70 °C. The disadvantages of this method are: the loss of flavor, a brownish or dark color, poor rehydration, all due to the long drying time and mushroom overheating (Giri *et al*., 2007). Even in the case of drying, the mushrooms need to be pretreated by blanching for the inactivation of the polyphenol oxidase enzyme. Usually, for *Pleurotus ostreatus* and *Agaricus bisporus* the enzyme inactivation occurs by boiling in water between 1 and 3 minutes (Arora *et al*., 2003).

Dried mushrooms can be used in dishes with a certain amount of water where they rehydrate (soups, stocks, sauces, stews, braised). Also, they can be rehydrated before use in various dishes, instead of fresh ones. Dried mushrooms can be used as important ingredients in many food formulas such as in instant soups, pasta salads, meat, snack

seasonings, stuffing, casseroles and rice dishes (Arora *et al*., 2003; Tuley, 1996).
The purpose of this paper is to determine some physicochemical parameters and sensorial characteristics of air-dried *Agaricus bisporus* and *Pleurotus ostreatus* mushrooms at 40°C.

2. MATERIALS AND METHODS

Material

Two mushroom species were studied: *Agaricus bisporus* and *Pleurotus ostreatus*. They were bought packaged in a refrigerated state from a local market. Before drying, they were subjected to a minimum processing: washing in cold water, blanching in hot water at 95 to 99°C for 5 minutes, water cooling at 15 to 20°C, cutting in five millimeter slices using a professional slicer (KuchenProfi, Germany). All those operations represent the mushrooms pretreatment. Afterwards the mushrooms were dried using the ITM dryer (Bucuresti, Romania) at 40 °C for 12, 24, 36 and 48 hours and stored in a dark room at 20 ± 2°C.

Physicochemical evaluation

Dried samples of *Pleurotus ostreatus* and *Agaricus bisporus* were subjected to several analyses: moisture at 105°C using ITM 50 oven (Bucuresti, Romania) and total protein using UDK 130 D distilling unit (Velp Scientifica, Italy) by AOAC (1995) methods, reducing sugar by Luff-Schoorl titrimetric method (CE, 2009), ascorbic acid by the iodometric method described by Suntornsuk *et al*. (2002), and niacin by AOAC (1995) 961.14 method using the DR/2010 spectrophotometer (Hach, U.S.A.) at 436 nm. All the chemical parameters values of mushrooms were reported on the dry weight content.

Sensorial evaluation

We applied the Romanian standard referring to the general guidance on establishing a sensorial profile according to SR EN ISO 13299:2010. The sensorial attributes and the quality of dried mushrooms are presented according to Baston *et al*. (2014).

Statistical data treatment

For the determination of mean and standard deviations in the case of chemical evaluation, the statistical analysis was performed using Microsoft Excel 2010. It was also used for the simple linear regression analysis between the drying time and the chemical parameters analyzed for each studied mushroom. The statistical significance was $P<0.01$. Five determinations were made for physicochemical samples (n=5). For sensory evaluation three replications for each attribute (n=3) were performed.

3. RESULTS AND DISCUSSION

In table 1 the moisture amount of dried mushrooms at various drying times is presented.

Table 1: Moisture variation in mushrooms after drying (mean ± SD)

Mushroom	Moisture content (%)				
	Pretreated	*12 hours*	*24 hours*	*36 hours*	*48 hours*
Agaricus	84.14±2.85	13.50±1.62	10.25±1.79	8.43±0.58	5.16±0.41
Pleurotus	88.93±3.38	7.48±2.57	5.89±1.41	3.95±0.77	1.98±0.69

SD-standard deviation

The air-drying method of preservation is a heat and mass transfer process between mushrooms and the heated air, and the purpose of the drying process is to reduce the moisture amount from the mushrooms as much as possible. From the data presented in table 1, after 12 hours of drying, there is a very high loss of moisture, 84 % for *Agaricus* and 92 % for *Pleurotus*. After the first 12 hours of drying, the moisture decrease is slower. At the end of our study, after 48 hours of drying, the moisture loss is of 94% for *Agaricus* and 98% for *Pleurotus*. This decrease of moisture is due to water removal (Wilhelm *et al*, 2004).

According to Tsotsas and Mujumdar (2011), the drying temperature and the air (especially the oxygen content of the air) induce a wide range of biochemical reaction in vegetables, such as: Maillard reactions, vitamin degradation, oxidations, denaturation of thermally unstable proteins and even enzyme reactions. In figure 1 the mean values of reducing sugars decrease significantly ($P < 0.01$) with increasing drying times for both species of mushrooms. The value of 0 drying time refers the mushrooms subjected only to minimal processing before drying (control sample).

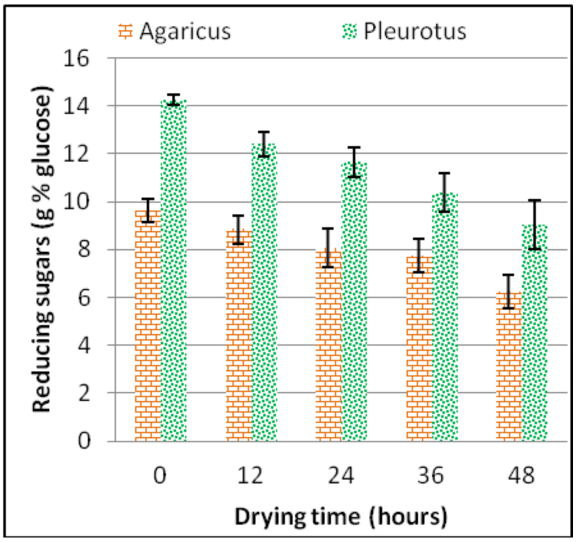

Fig. 1. Reducing sugars amount of dried mushrooms

After 12 hours of drying there was a reduction in the content of reducing sugars by 8 % for *Agaricus* and by 13 % for *Pleurotus*. This is due to the fact that a low drying temperature does not eliminate the risk of a Maillard reaction, but it greatly delays its occurence. Food drying refers to water removal and therefore the amount of nutrients will increase because they concentrate in the product. The decrease of the nutrients content after drying is due to the fact that the results were calculated on 100 g of dry matter. Even if the nutrient content remains constant in the dried food, due to humidity decreasing at drying, the amount of nutrients will decrease because the results were calculated on a dry basis. As presented in figure 1, the prolongation of drying periods of time decreases more the content of reducing sugars. Thus, after 48 hours of drying *Agaricus* presented a decreasing in the reducing sugars amount by 35 %, and *Pleurotus* by 36.5 %, values reported to control sample. For this reason it is recommended that the time of drying be reduced and the final moisture to be lower than 7.0 %, because the Maillard reaction is triggered by the presence of water or any traces of water (Monajjemzadeh *et al*., 2009).

Mushrooms are a good source of valuable proteins. Figure 2 shows the variation of protein content that is significantly ($P<0.01$) decreasing in time, for both species of mushrooms.

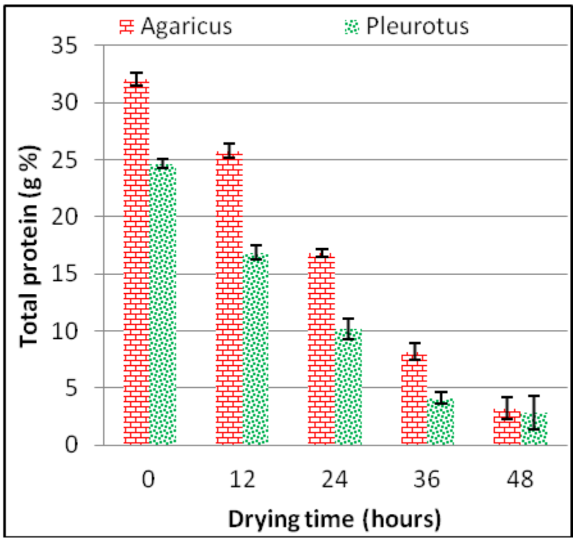

Fig. 2. Total protein amount of dried mushrooms

After 48 hours of drying at 40 °C the reduction of protein content is very high due to the water removal and possibly to the Maillard reaction or to the denaturation of thermally unstable proteins (Tsotsas and Mujumdar, 2011), being of 90 % for *Agaricus* and 88.5 % for *Pleurotus*. We strongly recommend that for the reduction of nutritive loss in proteins and reducing sugars to not extend the drying period more than 12 hours. Data from figure 2 show that after 12 hours of drying, the protein loss of mushrooms is of

7.5 % for *Agaricus* and of 13.5 % for *Pleurotus*. We have to correlate the losses in proteins with the moisture losses, because after 12 hours of drying there was a significant loss of moisture: 84 % for *Agaricus* and 91.6 % for *Pleurotus*. This moisture loss values are sufficient to increase the mushrooms shelf life.

Even if the drying temperature is low (40 °C), applying the convective air-drying method for mushroom preservation will result in nutritional value reduction. This is observed furthermore in figure 3 for both studied mushrooms, where the ascorbic acid is reduced during the drying period.

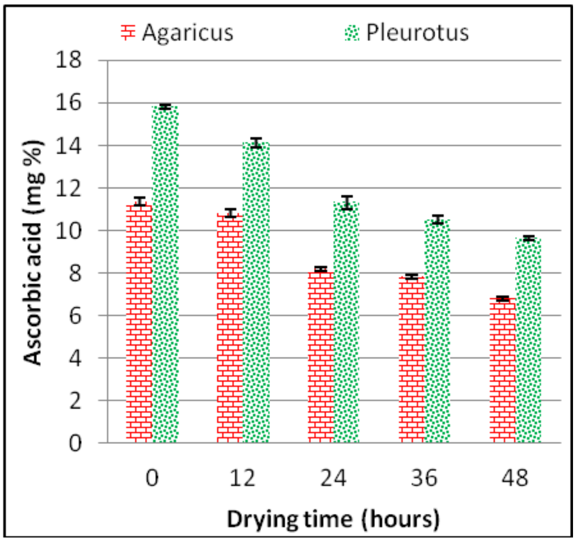

Fig. 3. Ascorbic acid amount of dried mushrooms

The initial low content (at 0 drying time) of ascorbic acid is due to the blanching operation that took place in boiling water for 5 minutes. Because the ascorbic acid is a water soluble vitamin, it can be lost in blanching water. Tsotsas and Mujumdar, (2011) state that, under air-drying action, the ascorbic acid can be oxidized to dehydroascorbic acid, followed by hydrolysis and further oxidation. All those actions contribute to a low initial content, before drying of vitamin C in both studied mushroom species. Moreover, the ascorbic acid loss is temperature dependent (Fennema, 1975). After 12 hours of drying and calculating the results based on the control sample, the content of ascorbic acid decreased by 5 % in *Agaricus* and by 10.7 % in *Pleurotus*. Also, after 48 hours of drying there was a 40.4 % decrease for *Agaricus* and 39 % for *Pleurotus*. For the ascorbic acid preservation, the reduction of drying time for less than 12 hours is recommended.

According to figure 4, niacin is stable to the action of physical agents (air oxidation, temperature). The amounts of niacin for both mushrooms species are decreasing significantly ($P < 0.01$) during the drying periods. The losses of niacin along drying period are reduced.

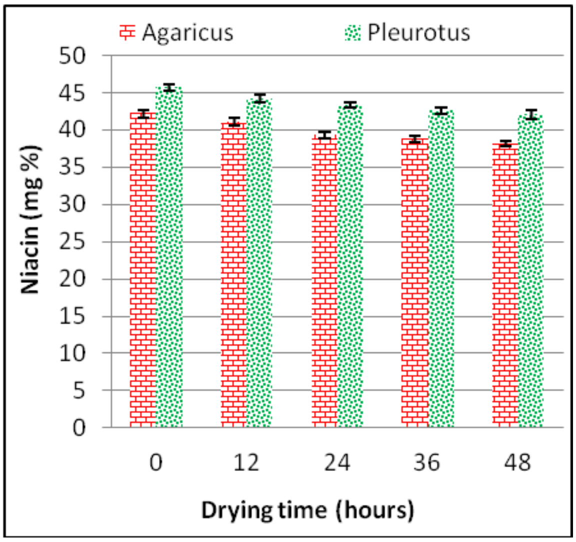

Fig. 4. Niacin amount of dried mushrooms

From figure 4, after 12 hours of drying, *Agaricus* mushrooms presented a 2.7 % loss and after 48 hours of drying a loss of 10 %. *Pleurotus* presented a 3 % loss after 12 hours of drying and after 48 hours of drying a loss of 8 %. Niacin seems to be resistant to the blanching treatment and drying temperatures.

After drying, the mushrooms presented some sensorial changes in flavor, taste, firmness and appearance, as presented in figure 5 and 6.

The panelists assessed both mushrooms species after 12 hours of drying as well. Only firmness in the case of *Agaricus* was pleasant. However, after 48 hours of drying firmness improved. *Agaricus bisporus* presented an improvement only in firmness with the increasing of the drying time and *Pleurotus ostreatus* presented an increasing in firmness and taste. The firmness increasing is due to water removal and the Maillard reactions can be the cause of taste improvement.

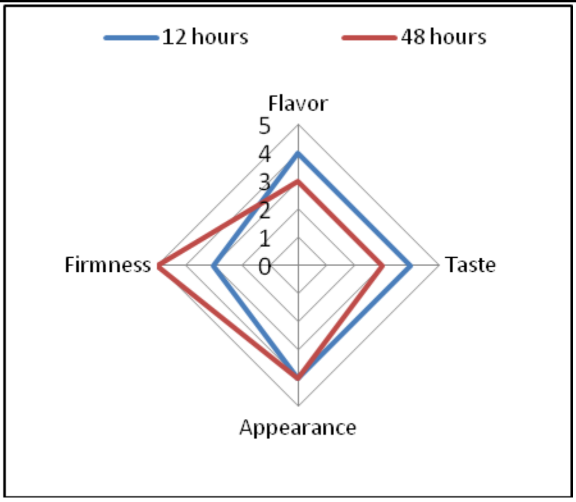

Fig. 5. ***Agaricus bisporus*** **sensorial analysis**

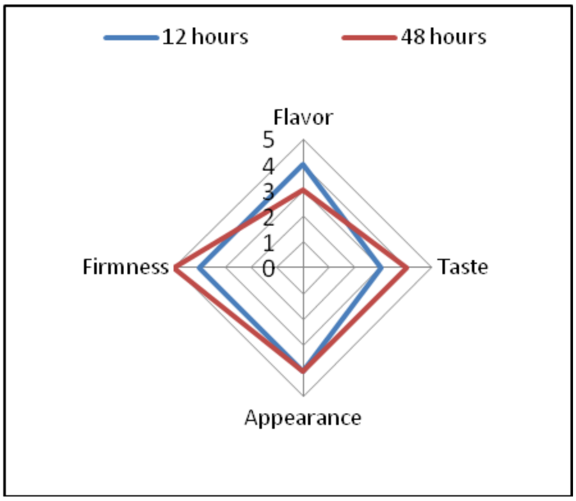

Fig. 6. ***Pleurotus ostreatus*** **sensorial analysis**

The changing in appearance (color) is possibly due to the enzymatic activity and chemical reactions (Maillard). For example, peroxidases play an important role in changing the taste and color directly by the substrate cleavage (Hui *et al*., 2004) and indirectly by the ascorbic acid oxidation and by the redox potential disturbance. Also, the Maillard reaction produces some substances that can affect the taste, flavor and color in a better or a worse way (Tsotsas and Mujumdar, 2011). All the chemical and enzymatic transformations that took place in the drying process of mushrooms explained the reduction of sensorial characteristics.

4. CONCLUSION

Air-drying mushrooms at 40 °C produced chemical and sensorial transformations to the studied mushrooms.
The moisture of mushrooms rapidly decreases within the first 12 hours of drying. Also the reducing sugars and proteins are decreasing along drying time. There is a loss in vitamins and the most affected is the ascorbic acid. Niacin was more temperature resistant than the ascorbic acid. From a sensory point of view, there were some changes in taste and flavor, the mushrooms presented slight darkening and apparent changes in firmness. In order to better preserve some nutritive characteristics of mushrooms we do not recommend the extension of the drying time over 12 hours, even at a low temperature.

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