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**RESEARCH ARTICLE**

# COMPARATIVE RESEARCH FOR THE INFLUENCE OF DRYING TECHNOLOGY ON THE CHEMICAL COMPOSITION OF SHIITAKE (*LENTINUS EDODES*) AND OYSTER MUSHROOMS (*PLEUROTUS OSTREATUS E.*)

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**ABSTRACT**

The aim of this research was to determine the differences in the chemical composition between fresh and dried *shiitake* and *oyster* mushrooms. The quality properties were determined by determining the mechanical and the chemical properties. The research was done in 2013. Drying was made in ventricular drier with heated air. The principle of drying is accurately performed to obtain characteristic odor and appearance of the mushroom. All of determined components had higher values in both of dried *shiitake* and *oyster* mushrooms, compared with fresh ones. The content of total dry matters was higher in dried *oyster* mushrooms (93.10%) and *shiitake* mushrooms (92.20%) compared with fresh mushrooms (23.10% in *oyster* mushrooms, and 25.20% in *shiitake* mushrooms). The content of total acids in dry *oyster* mushrooms was 0.40%, but in *shiitake* mushrooms was 0.48%. Its value in fresh *oyster* mushrooms was 0.13% and in *shiitake* mushrooms was 0.16 %. The content of vitamin C in dried *oyster* mushrooms was 14.10 mg/100g, and 13.53 mg/100 g in *shiitake* mushrooms. In the fresh *oyster* mushrooms the value of vitamin C was 9.20 mg/100 g i.e. 8.24 mg/100 g in the fresh *shiitake* mushrooms.
The value of mineral matters in dried *oyster* mushrooms was 4.50% and in dried *shiitake* mushrooms was 4.80%. The value of mineral matters was 0.90% in fresh *oyster* mushrooms and 1.00% in fresh *shiitake* mushrooms.
Drying in ventricular drier is fast method which reduces the necessary water quantity, inactivates the enzymes and reduces microorganism's metabolism. This is a basic principle in product conserving and storage for a longer period.



## INTRODUCTION

Mushrooms are terrestrial organisms, without chlorophyll, eukaryotic and saprophytic ogranisms (Royse *et al*., 1985; Turner, 1988). Their fruitful bodies are excellent food for human nutrition. They have exotic taste and pronounced aromatic smell. They can be used both in fresh and in processed form.

*Shiitake* mushrooms (*Lentinus edodes*) have an origin from south Asia, China and Japanese, and the first written records were found 2000 years ago. This kind of mushrooms was grown approximately 300 years ago (Chang, 1987). In Asia, *shiitake* mushrooms were known for its characteristic smell, taste and medicinal properties.

The beginnings of cultivation of *shiitake* mushrooms are recorded in Sung Dynasty of China (year of 960).

In the nature, this kind of mushrooms grow on dry and broadleaf trees, on the shii tree (*Castanopsis cuspidate*), as well as in many kinds of oaks and beeches (Burnett, 1988).

In Europe, the first producers of *shiitake* mushrooms appeared in 20th century. The knowledge for the big value of this mushroom as food, and especially as raw for pharmaceutics industry, is the main reason for intensive the new technologies adapted on the European areas (Harris, 1986).

Systematically, *shiitake* mushroom belongs to the class *Basidiomycetes*, underclass *Holobasidiomycetes*, genus *Agaricales*, row *Lentinus* and kind *Lentinus edodes*.

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Very important factor in production of *shiitake* mushrooms is having adequate nutrition, because it has big influence on the yield, the size of biomass, and the time between yields, too (Choi *et al*., 2006). Commonly used substrates are straw, compost, sawdust or other organic matter.

*Shiitake* mushrooms have excellent nutritive values. The nutritive matters from the mushrooms have three basic functions in the human body, such as: building function, energy source and protecting mechanism (Turło *et al*., 2010). *Shiitake* mushrooms are source of mineral matters, vitamins and essential amino acids, too. The nutritive values of the mushrooms depend on the origin of the mycelium from the substrate, conditions and the methods of growth. On the other hand, in *shiitake* mushrooms there are antibiotic substances, too (Chang and Miles, 2004).

In the Republic of Macedonia, *shiitake* mushrooms are grown in very small areas. But the rise in production by applying modern technology in the processing industry is growing.

*Oyster* mushroom (*Pleurotus ostreatus* E.) is an important edible mushroom which is widespread in the Republic of Macedonia. It is found in temperate forests and is growing arranged side by side and one above the other. This mushroom grows after heavy rains, when the weather will slightly warm, but also in cold periods of the year (Sonali and Randive, 2012; Oseni *et al*., 2012). It grows in the winter when other mushrooms are rarely encountered. *Oyster* mushroom is saprophyte that grows on logs, fallen trees, and pieces of trees that remain after the cutting of the forest (Shah *et al*., 2004). *Oyster* mushroom draws very healthy and nutrient needs from the trees that are using for growth and development, and these substances favorably affect the human body (Ahmed, 1986; Caglarirmak, 2007).

*Oyster* mushroom is easily recognized. It has light brown color with a characteristic shape as shell. The meat is white and firm elastic, with a pleasant taste and distinctive smell, very favorable for processing (Bonatti *et al*., 2004; Khydagi, 1998). *Oyster* mushroom can be produced on wheat straw, corn cobs, sawdust, and trunks of deciduous trees. It is best grown on a substrate of pure chopped wheat straw, or with the addition of 10% meadow hay or cut corn cobs (Das and Mukherjee, 2007). It can be produced and logs of poplar, birch and bone, as well as in logs of deciduous trees - beech and oak. *Oyster* mushroom can be produced throughout the year on a relatively small area in a short cycle (Dundar *et al*., 2009; Sun and Jian-Jun, 1989).

Depending on the strain, *oyster* mushroom can grow at a temperature of 5 - 15°C or 18 - 28°C. During the production takes place in moderate humidity wetting the substrate surface (but not in the fungus). If there is not enough lighting, additional lighting with ultraviolet light is used (12 hours light and 12 hours of darkness).

*Oyster* mushroom should be picked while it is young and soft. Fruit is growing in waves within 10-14 days. Most fruit has the first and second wave. The total yield is about 20% by weight of the substrate.

According to the nutritional value *oyster* mushroom takes place between vegetables and meat, and it is closer to the meat (Eswaran and Ramabadran, 2000). This mushroom is rich in vitamins, has prominent smell and taste and often reaches sizes up to 20 cm in diameter.

The beneficial effects of *oyster* mushrooms have been discovered by the Chinese, where today commonly used is dried or powdered, and Europeans began to use in the end of the last century. In its composition *oyster* mushroom contains vitamins: B, D, C, K, proteins, minerals - iodine, selenium, sodium, potassium, zinc, phosphorus, and iron (Mattila *et al*., 2001; Patil *et al*., 2010). Additionally it contains chlorophyll which accelerates the regeneration of cells, and has fiber that bind and ejecting waste products from the body (Bano, 1976). The chemical content of the mushrooms has an essential importance for human nutrition as well as for choosing of technological method for processing. It has an influence on the final products (Baughman, 1989). From the processed forms, the most used is dried mushroom.

The aim of this research was to determine the differences in the chemical composition between fresh and dried *shiitake* and *oyster* mushrooms.

## MATERIALS AND METHODS

In this research, as a work material were used fresh and ventricular dried *shiitake* and *oyster* mushrooms. In the Republic of Macedonia *shiitake mushrooms* grow in very small quantities, but *oyster* mushrooms are widespread in this territory. Both of mushrooms for this research were picked from Baba Mountain. *Shiitake* mushrooms were picked in April 2013 and *oyster* mushrooms were picked in the begining of September 2013. Both of them were picked when the cap was approximately 70 percent open that is when the mushroom caps were still slightly curled under. The quality properties of the analyzed mushrooms were determined with determining the mechanical and the chemical properties. Research was made in 2013.

The mechanical properties were determined only in fresh *shiitake* and *oyster* mushrooms. From the mechanical properties were determined the diameter of the mushroom cap and the length of the mushroom stalk.

The chemical content of fresh and dried mushrooms was determined. The drying was made in the ventricular drier with heated air. The principle of drying was accurately performed to obtain characteristic odor and appearance of the mushroom.

The following chemical properties of fresh and dried *shiitake* and *oyster* mushrooms were determined:

- Content of total dry matter - determined by drying the material in dryer at a temperature of 105°C (Sarić *et al*., 1989);
- Moisture content – determined by calculation that 100 % will be deducted % of total dry matter;
- Content of vitamin C - determined by the Thilmans method based on the redox reaction between L-ascorbic acid and organic color 2.6 dichlorophenolindophenol;
- Total acid content - determined by the method of neutralization with 0.1 M NaOH solution in the presence of the indicator 1 % solution of phenolphthalein indicator;
- Content of total carbohydrates - determined by HPLC method;
- Content of mineral matter (ash) - determined with material burning at a temperature of 500 °C;
- Content of nitrogen (N) - determined using Kjeldhl method (Sarić *et al*., 1989);
- Content of phosphorus ($P_2O_5$) - determined by using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić *et al*., 1989);
- Content of potassium ($K_2O$) - determined by incineration of the material with concentrated $H_2SO_4$ and plamenfotometar (Sarić *et al*., 1989);
- Content of calcium (SAT) - determined by using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić *et al*., 1989);
- Content of magnesium (Mg) - determined by applying atomic; emission spectrometry with inductively coupled plasma (ICP - AEC) (Sarić *et al*., 1989);
- Proteins – determined with calculation when the % N is multiplying with coefficient 6.25.

In the dried *shiitake* and *oyster* mushrooms were made two pretreatments, and three variants were getting: variant M1 – control variant; variant M2 – where the pretreatment was made with 2% solution of ascorbic acid for 5 minutes; variant M3 – where the pretreatment was made with 3% solution of potassiummetabisulphite for 5 minutes. The content of mineral matters nitrogen, phosphorus, potassium, calcium and magnesium was analyzed only in the variants of dried *shiitake* and *oyster* mushrooms.

## RESULTS AND DISSCUSION

The mechanical and the chemical content are specific for each kind of mushrooms. The mechanical properties are basic requirement for cost-effective production of mushrooms. Size is an important characteristic for each mushroom kind. By analyzing the mechanical properties, is determined the weight ratio of separate parts of the mushrooms (cap diameter and stalk length) in percentage (San and James, 1981; Wilcke *et al*., 1989). Chemical composition of the mushrooms means the content of all ingredients in the mushroom including the water (Brauer *et al*., 2002).

The mechanical properties were determined with measuring of 50 *shiitake* and 50 *oyster* mushrooms. According to the results of measuring was determined that the average cup diameter of *shiitake* mushrooms was 8.60 cm and the average stalk length of *shiitake* mushrooms was 4.10 cm.

The average cup diameter of *oyster* mushrooms was 7.35 cm and the average stalk length of *oyster* mushrooms was 3.20 cm. Ajonina and Tatah (2012) observed that the stalk length of *oyster* mushrooms is 2.43 to 3.24 cm.

The results of the chemical composition of both *shiitake* and *oyster* mushrooms are shown in the tables.

**Table 1** Chemical composition of fresh *shiitake* and *oyster* mushrooms

| Components | Fresh *shiitake* mushrooms | Fresh *oyster* mushrooms |
|---|---|---|
| Total water (%) | 74.80 | 76.10 |
| Total dry matters (%) | 25.20 | 23.10 |
| Total acids (%) | 0.16 | 0.13 |
| Vitamin C mg/100g | 8.24 | 9.20 |
| Mineral matters (ash) (%) | 1.00 | 0.90 |
| Total carbohydrates (%) | 4.20 | 5.00 |

**Table 2** Chemical composition of dried *shiitake* mushrooms per variants

| Components | M1 | M2 | M3 |
|---|---|---|---|
| Total water (%) | 7.80 | 7.90 | 7.95 |
| Total dry matters (%) | 92.20 | 92.10 | 92.05 |
| Total acids (%) | 0.48 | 0.43 | 0.40 |
| Vitamin C mg/100g | 13.53 | 14.70 | 13.00 |
| Mineral matters (ash) (%) | 4.80 | 4.70 | 4.65 |
| Total carbohydrates (%) | 7.10 | 6.40 | 6.60 |
| N (%) | 2.10 | 1.70 | 1.80 |
| P (%) | 1.29 | 0.90 | 1.00 |
| K (%) | 1.15 | 1.10 | 1.26 |
| Ca (%) | 4.15 | 4.00 | 4.02 |
| Mg (%) | 2.58 | 2.40 | 2.50 |
| Proteins (%) | 13.16 | 10.63 | 11.25 |

**Table 3** Chemical composition of dried *oyster* mushrooms per variants

| Components | M1 | M2 | M3 |
|---|---|---|---|
| Total water (%) | 6.90 | 6.95 | 7.20 |
| Total dry matters (%) | 93.10 | 93.05 | 92.80 |
| Total acids (%) | 0.40 | 0.39 | 0.37 |
| Vitamin C mg/100g | 14.10 | 14.50 | 13.80 |
| Mineral matters (ash) (%) | 4.50 | 4.30 | 4.00 |
| Total carbohydrates (%) | 7.80 | 6.60 | 7,00 |
| N (%) | 2.70 | 2,10 | 1.95 |
| P (%) | 1.40 | 1,05 | 1.10 |
| K (%) | 1.20 | 1.15 | 1.35 |
| Ca (%) | 3.90 | 3.75 | 3.60 |
| Mg (%) | 2.50 | 2.38 | 2.40 |
| Proteins (%) | 16.96 | 13.19 | 12.25 |

From the data shown in Table 1 and Table 2, can be concluded that the content of total water was higher in the fresh mushrooms where its value was 74.80%, and in the dried mushrooms the highest content of total water had variant M3 (7.95%). Chang and Miles (2004) found that the content of total water in fresh *shiitake* mushrooms is 76.50 - 78.50%. The content of total dry matters is in correlation with the content of total water and its value was 25.20% in the fresh, but 92.20% in the variant M1 from dried *shiitake* mushrooms. Fresh *shiitake* mushrooms had lower content of total acids (0.16%) compared to dried mushrooms from the variant M1 (0.48%). The vitamin C in fresh mushrooms was presented with 8.24 mg/100g and in dried *shiitake* mushrooms the content of vitamin C was the highest in variant M2 (14.70 mg/100g)

where the pretreatment was made with 2% solution of ascorbic acid. According to Turło *et al*. (2010) the content of vitamin C in fresh *shiitake* mushrooms is 7.30 mg/100g. Fresh *shiitake* mushrooms contained 1% mineral matters, compared to dried mushrooms from the variant M1, where its content was 4.80%. The content of total carbohydrates in the fresh mushrooms was lower (4.20%), compared to dried *shiitake* mushrooms from the variant M1 (7.10%). The content of mineral matters: nitrogen (2.10%), phosphorus (1.29%), calcium (4.15%) and magnesium (2.58%) were the highest in dried *shiitake* mushrooms from the variant M1. The content of potassium (1.26%) was the highest in dried mushrooms from the variant M3, where the pretreatment was made with 3% solution of potassiummetabisulphite. The content of proteins is in correlation with the nitrogen content, and its value was the highest in dried *shiitake* mushrooms from the variant M1 (13.16%).

From the data shown in Table 1 and Table 3, can be concluded that the content of total water was higher in the fresh mushrooms where its value was 76.10%, and in the dried mushrooms the highest content of total water had variant M3 (7.20%). The content of total dry matters is in correlation with the content of total water and its value was 23.10% in the fresh, but 93.10% in the variant M1 from dried *oyster* mushrooms. Fresh *oyster* mushrooms had lower content of total acids (0.13%) compared to dried mushrooms from the variant M1 (0.40%). According to Patil *et al*. (2010) the content of total dry matters in dried *oyster* mushrooms with no pretreatments is 91.00-94.00%. The vitamin C in fresh mushrooms was presented with 9.20 mg/100g and in dried *oyster* mushrooms the content of vitamin C was the highest in variant M2 (14.10 mg/100g) where the pretreatment was made with 2% solution of ascorbic acid. Fresh *oyster* mushrooms contained 0.90% mineral matters, compared to dried mushrooms from the variant M1, where its content was 4.50%. The content of total carbohydrates in the fresh mushrooms was lower (5.00%), compared to dried *oyster* mushrooms from the variant M1 (7.80%). Mattila *et al*. (2001) found that the content of total carbohydrates in fresh *oyster* mushrooms is 5.50-6.50%. The content of mineral matters: nitrogen (2.70%), phosphorus (1.40%), calcium (3.90%) and magnesium (2.50%) were the highest in dried *oyster* mushrooms from the variant M1. The content of potassium (1.35%) was the highest in dried mushrooms from the variant M3, where the pretreatment was made with 3% solution of potassiummetabisulphite. The content of proteins is in correlation with the nitrogen content, and its value was the highest in dried *oyster* mushrooms from the variant M1 (16.96%).

## CONCLUSION

Based on this research and the results for determining the influence of ventricular drying technology on the chemical composition of *shiitake* and *oyster* mushrooms, can be concluded that in both of *shiitake* and *oyster* mushrooms M1 variant, which had no pretreatment, was characterized with the best chemical composition. *Shiitake* mushroom had higher content of total water, total acids, mineral matters, calcium and magnesium in M1 variant. The content of the other parameters: total dry matters, vitamin C, total carbohydrates, nitrogen, phosphorus, potassium, calcium and proteins were higher in M1 variant of *oyster* mushrooms.

From the presented data can be concluded that both of the mushrooms are suitable for ventricular drying, because their chemical composition after drying does not change in negative direction. *Oyster* mushrooms were characterized with better chemical composition, but on the other hand they are widespread in the Republic of Macedonia, compared to *shiitake* mushroom. Because of that, *oyster* mushrooms are recommended for consummation, as food with rich chemical composition and excellent nutritive values.

Ventricular drying is in the initial stage in our country. With the introduction of ventricular dryers in general practice will increase the income of farmers, production, employment and foreign exchange inflow into the country.

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