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The use of freeze-dried mushrooms in instant food preparations

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Abstract
Lyophilization is a preservation process, consisting of the sublimation of water with the help of vacuum. The advantage of this method, is that, the mushrooms retain all their nutritional properties. Edible mushrooms have a multitude of benefits for human health. They contain a number of nutrients, some of which are a real therapeutic support. Due to the fact that the preparation of freeze-dried foods is extremely simple, recently, the assortment of instant foods has diversified a lot, including those based on dried mushrooms. In the study carried out, two edible species of mushrooms from the spontaneous flora (*Marasmius oreades* and *Boletus edulis*) were used, which were subjected to lyophilization, then their rehydration capacity was increased. The lyophilized *Boletus edulis* species presented a rehydration capacity of 98.50%, and the *Marasmius oreades* species 96.75%, both species presenting excellent taste characteristics in various culinary preparations.

Key words: freeze-dried mushrooms, instant food, *Marasmius oreades*, *Boletus edulis*

Introduction

After, for more than five decades, the lyophilization process was used predominantly in the pharma field (for the preservation of vaccines, plasma etc.), the massive growth in recent years is due to the food industry [2]. More specifically, the use of this technology has evolved as more and more studies have appeared that confirm the superior quality of freeze-dried foods, compared to other food preservation techniques [6]. Other arguments in favor of freeze-dried foods are: the long warranty period, between 3 and 25 years, the very short preparation time (a few minutes), the lack of toxic and light food additives and the preservation of the original appearance of the food (Figure 1).

Some of the first evidence of the use of the freeze-drying process dates back several thousand years and was discovered in the Patagonian steppe at the top of the Andes [10]. The indigenous people here discovered that if they let vegetables freeze overnight and then exposed them to the sun during the day, they dried out quickly and spoiled much more easily [17]. Thus, the inhabitants of Peru at that time enjoyed a healthy and nutritious diet throughout the year [1].

Today, we use the same rules, but with the technology of the 21st century, which allows a superior preservation of food: very briefly, through the current technology of lyophilization, the food is frozen in a vacuum environment, and the water in the fibers is removed by sublimation (passing from the solid state directly in gaseous state) [18].

The lyophilization process is based on principles of biology and physics, namely: anabiosis, freezing and sublimation in a vacuum [7].

For a long time, attempts have been made to preserve microorganisms by drying, using physical or chemical factors [15]. The results obtained most of the time were not satisfactory because it was observed that in the case of evaporation drying of a microbial suspension, due to the gradual loss of water, a concentration of both salts and disassimilation substances from the respective environment is produced, which leads to the modification of the structure of the protein molecule, an irreversible phenomenon and incompatible with cellular life. Instead, this process proved useful in the preparation of the first rabies vaccine by Pasteur [8].

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If, however, the evaporation of water from the same microbial suspension is replaced by sublimation, which is produced by drying at low temperatures, under the action of vacuum or absorbent chemicals, after prior freezing, the microbes are no longer influenced, because the substances are not found in solution [11].

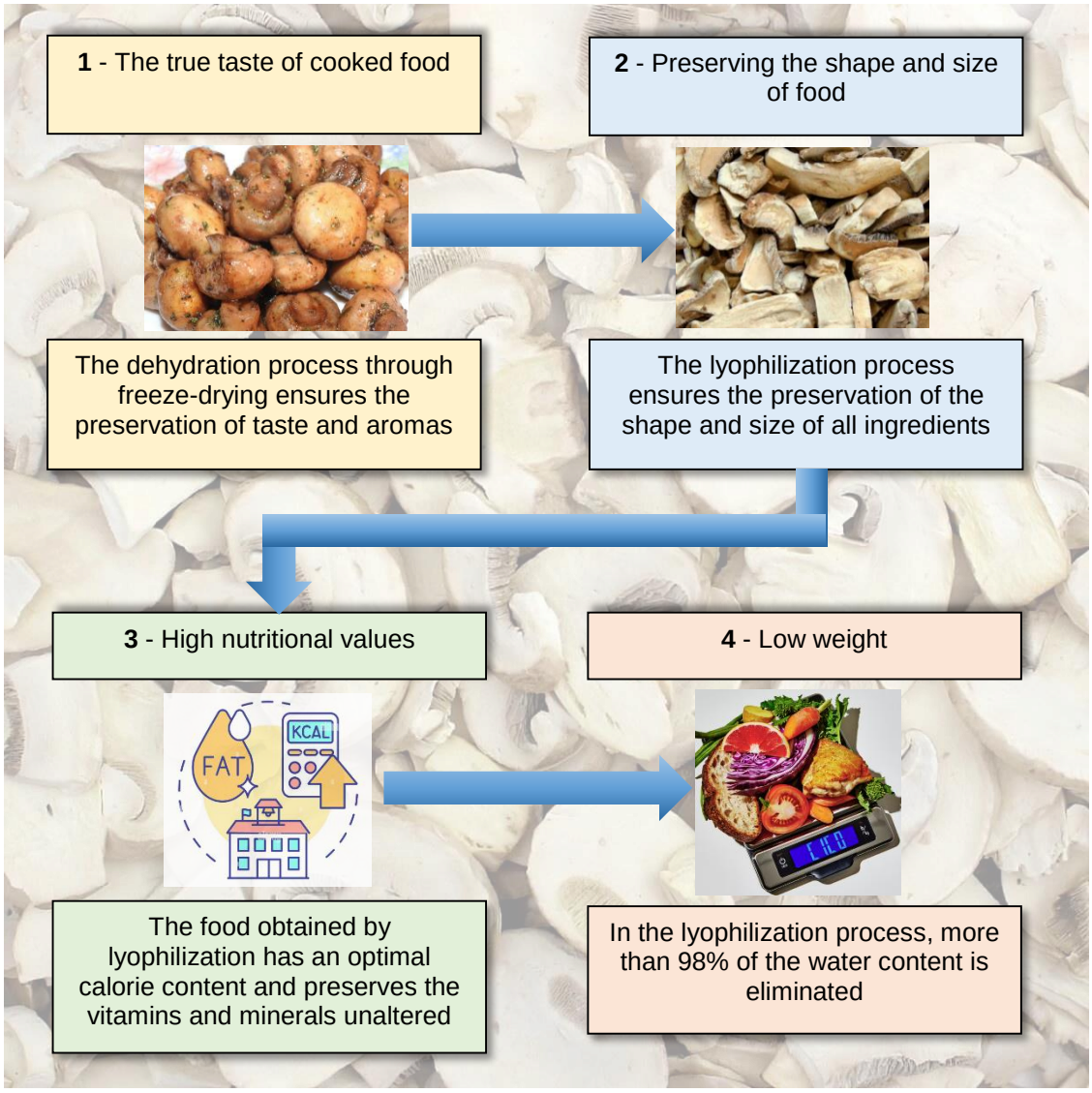

Figure 1. Freeze dryed food general characteristics.
Souce: original.

It is therefore about the application of a well-known principle in chemistry according to which substances are only active in solutions [3].

Another principle underlying lyophilization is the fact that the evaporation of a liquid or the sublimation of a solid is all the more active, the lower the pressure [12]. On the other hand, it is known that any evaporation or sublimation has the effect of decreasing the temperature, the more pronounced the decrease, the more active the evaporation or sublimation [16].

The drying that occurs in the case of lyophilization differs from evaporation, therefore from distillation, in that the loss of water occurs through the sublimation of vapors from the solid substance, while for distillation the substance must necessarily be in liquid form [9].

The basic characteristic of lyophilization is the direct passage of water from solid form (ice) to vapor form, so sublimation accompanied by the elimination of the formed vapors [13].

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The pressure of water vapor, which is exerted on the material subjected to drying, depends first of all on the temperature of this material, then on the size of its dry surface, on its intimate structure and finally on the way in which the water is chemically and physically bound in the structure of the material respectively [14].

Because it can be an excellent solution for any explorer to turn to when starting a hike, freeze-dried food deserves special attention. Easy to transport, it retains its taste and nutrients and can be prepared extremely quickly (Table 1). In this way, freeze-dried food will help you enjoy delicious and healthy food wherever you go [4].

Table 1. Properties of freeze-dry food compared to dedydrated food

Properties	**Freeze-dried food**	**Dehydrated food**
Weight	+ + +	+ + +
Nutritional values	+ + +	+
Space economy	+ +	+
Taste	+ + +	+
Price	+	+ +
Rehydration	5 min in hot water 5-10 min in cold water	5-20 min in hot water 1-2 hours in cold water

Source: https://dryfood.ro/

Preparing freeze-dried foods is extremely simple. All we have to do is remove the moisture absorbent bag from the package, then pour boiling water over it and wait for the time specified by the manufacturer on the package. After a few minutes, the food is ready to eat [5].

The packaging in which the product is placed is light and does not take up much space in the luggage. Most manufacturers also allow the preparation of food directly in the package, so that we do not have to take additional dishes with us.

Material and Method

In the study, two species of mushrooms were used: *Marasmius oreades* (Figure 2) and *Boletus edulis* (Figure 3), which were harvested from deciduous forests in Cluj County and presents the descriptive characteristics mentioned in the table (Table 2).

Figure 2. *Marasmius oreades*
Source: original.

Figure 3. *Boletus edulis*
Source: original.

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Table 2. Biological matterial used in the study

Description	*Marasmius oreades* (dew sponge)	*Boletus edulis* (cep, penny bun, porcino or porcini)
Hat:	2-7 cm diameter, convex at first, then flattens, central remains umboned, with wavy edge when mature, sometimes striated; cream, pale ochre, in the wet state with a darker edge, in the dry state lighter, with a smooth surface	5-25 (40) cm diameter; at first sterile, then spreading, dark brown or light, often spotted; surface smooth or finely rough, in wet adherent state
Lamellae / The sporiferous tubes:	Lamellae: adnate, spaced, thick, of different lengths; cream or ocher	The sporiferous tubes: when young with narrow pores, they detach easily from the cap; at first whitish, they become yellow-green, finally olive-green.
Leg:	4-7 cm long, 0.2-0.5 cm thick, cylindrical; of the color of the hat, darker in the lower part, with a pruinous surface	5-30 cm long, 2.5-6 cm thick; in different forms, from cylindrical to swollen: whitish, light brown; provided with a whitish network
The meat:	in the hat it is thin, elastic, in the leg strong and fibrous; whitish, with a pleasant spicy taste and smell	thick, hard at first, becomes soft over time; white, does not color, under the cuticle of the reddish hat, with a nutty taste and pleasant smell
Period of appearance:	April-December, in grassy areas, in the clearings of beneficial forests, often in circles of witches, appears quickly after rain, a common species	June-October, only on the acid soils of deciduous and conifer forests, a common species
Food value:	only the hat is edible, suitable for marketing, ideal for soups	edible, suitable for marketing
Related species:	the poisonous mushrooms *Inocybe rimosa* and *Clitocybe rivulosa*, the inedible mushroom *Gymnopus peronatus* and the edible mushroom *Gymnopus dryophilus*	the poisonous mushroom *Boletus radicans*, the inedible mushroom *Tylo pilus felleus*, the edible mushroom *Xerocomus badius* and the edible mushroom *Boletus reti culatus*, with the surface of the cap finely tormented

After harvesting, the biological material was cleaned, the inedible parts were removed, and then the biological material was subjected to freezing at a temperature of -25 ºC [21].

After freezing, the lyophilization process was started, using the LIO-2 FP lyophilizer from FreezeDry GmbH Germany (Figure 4).

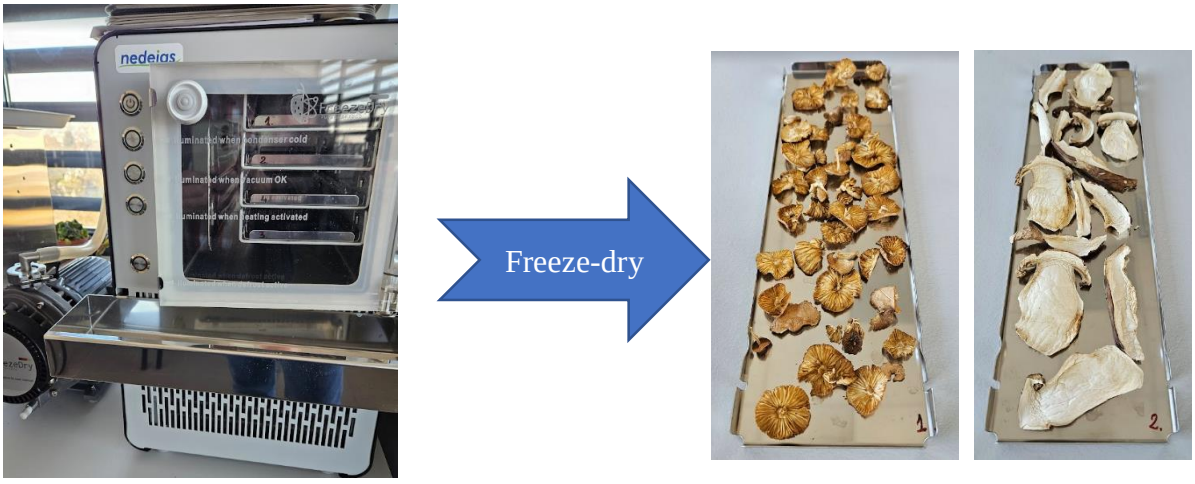

Figure 4. LIO-2 FP freeze dryer, and the obtained lyophilized product.
Source: Original.

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The lyophilization process lasted 24 hours, the condenser temperature being set at -60 ºC.

The physical-chemical determinations were carried out at the Faculty of Horticulture and Business in Rural Development from Cluj-Napoca, in the laboratory of the Horticultural Products Technology discipline, using measuring instruments (balance, meter, caliper etc.).

Biochemical determinations were also carried out on the biological material:

✓ Soluble dry substance (SDS) by the refractometric method [19];

✓ Carbohydrates by Bertrand method [20].

Results and Discussions

Forest mushrooms have been used for hundreds of years both as a main ingredient in the kitchen and in medicine. They are usually classified as vegetables, but they actually belong to the Fungi kingdom. Due to their high water content, fresh mushrooms are highly perishable, and because of this they must be prepared or preserved very quickly after harvesting.

In all processes of processing and industrialization of plant products, the first stage is the removal of inedible parts, traces of soil and other plant residues (Figure 5).

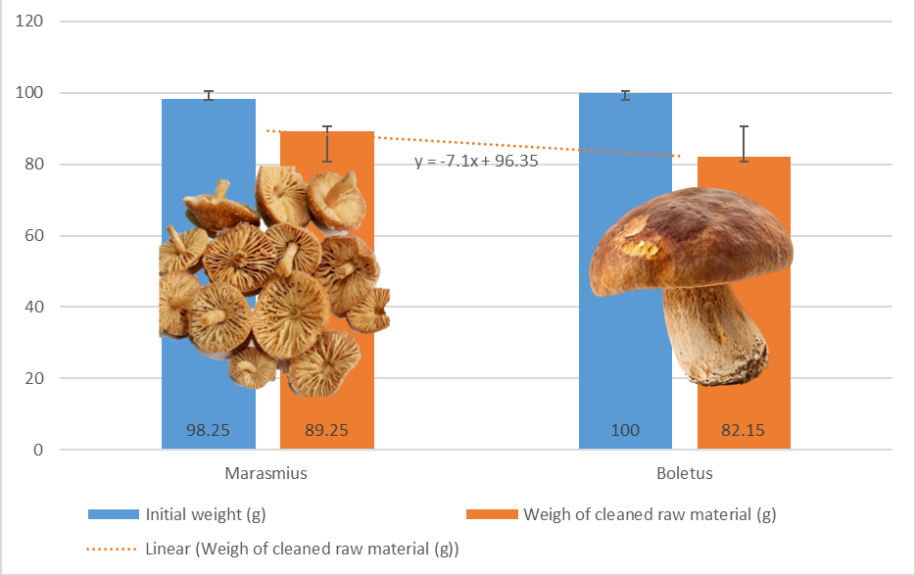

Figure 5. Evolution of the raw material mass after cleaning stages.

Following this technological process, a decrease in the mass of the raw material is recorded. In our case, a greater decrease was recorded in the species *Boletus edulis*, due to the fact that the sporiferous tubes were removed. The recorded losses were 17.85% for the *Boletus* species and 9.16% for the *Marasmius* species.

Drying of fruits and vegetables is the technological process by which the natural water content is reduced to a level that prevents the activity of microorganisms, without destroying the tissues or depreciating the food value of the products being dried. The ensemble of phenomena that occur during drying leads to the concentration of valuable principles, to the reduction of the volume of raw material used and to the increase of the food and therefore commercial value of the finished product.

The raw materials must retain their quality characteristics, especially the taste, appearance and nutritional components, and undergo as few changes as possible during drying. By dehydration, 90-95% of water is removed, while by lyophilization the average is 98-99%. The higher the percentage, the longer the life of the products.

That is why the maximum guarantee period for dehydrated foods is about 2-3 years, and for those that have gone through the freeze drying process, 3-20 years. This, even if they are stored in varying conditions and temperatures. Dehydration involves exposing food to dry air, thus eliminating any trace of moisture. Bringing it to such a high temperature can alter, however, both the taste and appearance, as well as the nutritional properties of the products - especially when it comes to vitamins A and C or the B-complex.

With freeze-drying, food (or previously cooked food) is placed in a vacuum environment, where the temperature gradually drops to below freezing point, after which it also gradually rises. Through this

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mechanism, water is transformed from liquid to vapor (without passing through the solid state), which maintains the original structure and composition of the food.

The data recorded during lyophilization for the two studied species are presented in Figure 6.

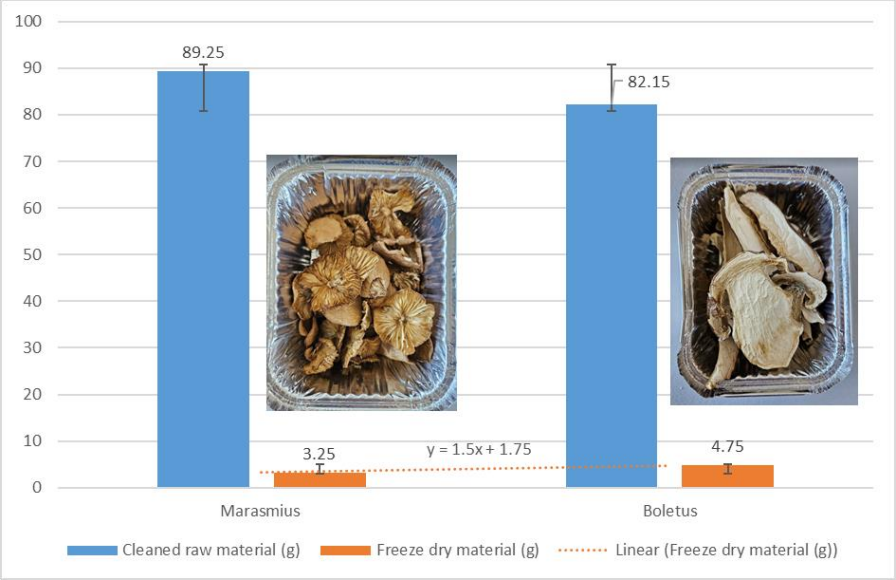

Figure 6. Data recorded during mushrooms lyophilization.

As can be seen from figure 6, the Marasmius species presented the highest percentage of water loss in the freeze-drying process of 96.36%, and the Boletus species recorded a water loss of 94.22%.

The quality of horticultural products preserved by dehydration is determined by establishing their rehydration power. If these products rehydrate more, thus having the ability to regain lost water, they are considered of superior quality.

The rehydration of the lyophilized samples was carried out for 24 hours at a temperature of 21 ºC. The data obtained are presented in Figure 7.

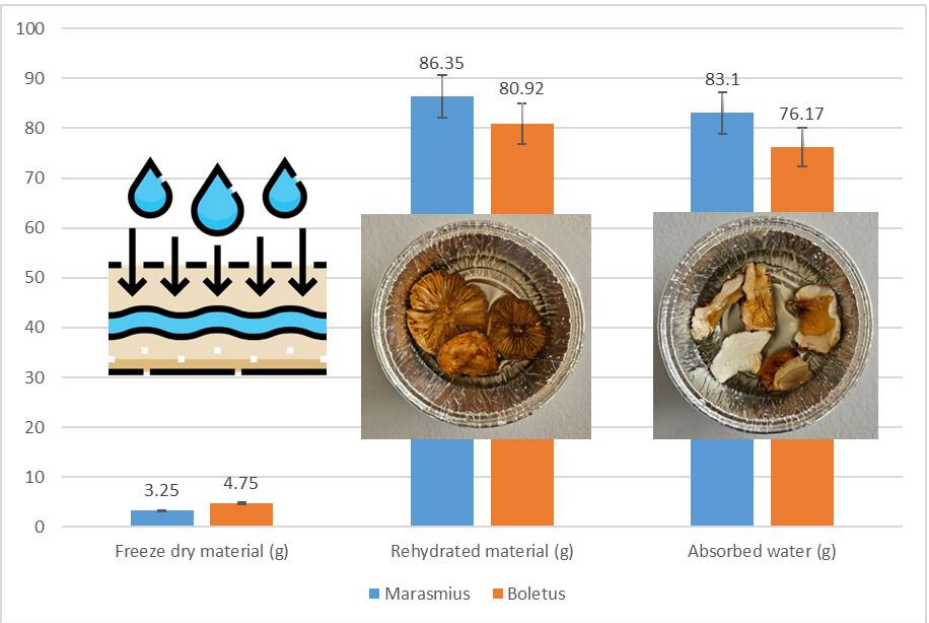

Figure 7. Data recorded during lyophilized samples rehidration.

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Following the experience, the *Boletus* species presented a rehydration capacity of 98.50%, and the *Marasmius* species of 96.75%. Although the recorded values are similar, the *Boletus* species has a greater capacity for rehistration due to its constitution and texture.

Regarding the chemical composition of the studied species, it can be observed that the Boletus species has 1.3% more dry matter than the Marasmius species (Figure 8).

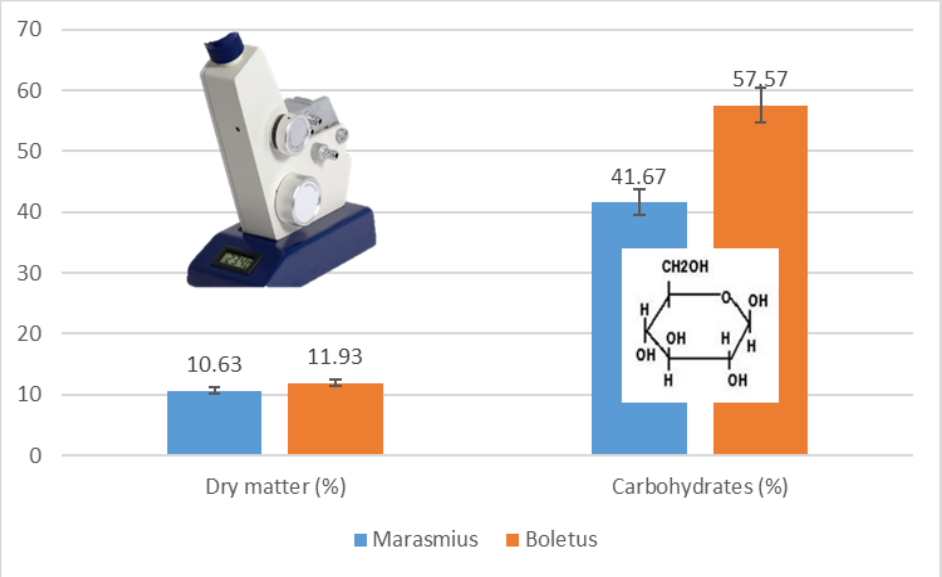

Figure 8. Dry matter and carbohydrates content of fresh samples.

Regarding the content of carbohydrates, these being in a direct correlation with the content of soluble dry matter, it can be observed that the Boletus species presents 15.9% more carbohydrates than the Marasmius species.

The data obtained by us are similar to those obtained by Kalak [5], who recorded for Boletus Species values of soluble dry matter between 11.6 and 12.2%, for carbohydrates 54.9 and 65.4%

Conclusions

Based on the experimental results obtained regarding the use of freeze-dried mushrooms in instant food preparations, the following can be concluded:

- ✓ both species of mushrooms studied have a very high rehydration capacity, and thanks to this fact they can be used in instant food preparations;
- ✓ the higher rehydration capacity of the *Boletus* species is due to the constitution and texture of the mushroom.

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