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CHANGES IN THE QUALITY PARAMETERS OF MUSHROOMS DEPENDING ON THE DURATION AND CONDITIONS OF STORAGE

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Abstract. The article presents the results of studying how the storage duration and conditions effect on changes in the quality of the mushrooms *Agaricus bisporus* of the strain IBK-25 and *Pleurotus ostreatus* of the strain NK-35. The changes in the quality of mushrooms were estimated before and after 6 days of storage by sensory, commercial (marketability), and chemical parameters. The temperatures of storage were -1, +1, +3 and +5°C, and the relative humidity was 90±1%. The quality of products was evaluated by their appearance, natural loss, output of marketable mushrooms, and by chemical parameters: the content of dry matter, protein nitrogen and ascorbic acid. The results of visual observations for 6 days have shown that the best storage temperature for mushrooms was 1°C. At -1°C, the *Agaricus bisporus* froze and were not suitable for use after defrosting, while the *Pleurotus ostreatus* restored their structure and, after sorting, could be processed. During 6 days of storage at 3°C, the quantity of marketable *Agaricus bisporus* decreased by 3.4 and 3.5% (depending on the flush), that of *Pleurotus ostreatus* by 3.4 and 3.8%, compared with the reference. At 5°C, the *Agaricus bisporus* decreased in the quantity of marketable mushrooms by 19.2 and 20.6%, and the *Pleurotus ostreatus* by 12.4 and 13.1%. After 6 days of storage at 5°C, the natural loss of the *Pleurotus ostreatus* was greater than that of the *Agaricus bisporus* mushrooms (as a result of their larger evaporation area), but nonmarketable *Pleurotus ostreatus* mushrooms were fewer (8.7–9.9%, compared with 17.7–19.3% of the *Agaricus bisporus*). At 1°C, the output of marketable mushrooms in both species was about the same, but at 5°C, it was higher by 9.0–9.4% in the *Pleurotus ostreatus*. Six days of storage changed the contents of some chemical substances in the *Agaricus bisporus*: dry matter and ascorbic acid decreased by 5.3–17.4% and by 7.4–25.9% respectively, though natural loss remained almost unchanged. Similar trends were observed in the *Pleurotus ostreatus*. Thus, as a result of our research, we recommend 1°C as the optimum temperature of storing *Agaricus bisporus* and *Pleurotus ostreatus* mushrooms, because it ensures retention of their sensory, marketability, and chemical parameters.

Keywords: mushrooms, *Agaricus bisporus*, *Pleurotus ostreatus*, duration of storage, marketability, natural loss, quality.

Introduction. Formulation of the problem

In Ukraine, as all over the world, the mushroom farming industry is developing intensively. This is because mushrooms are highly nutritious, their yields are consistently high, and their production can be organised as a continuous flow, with crops collected daily [1-4]. Their cultivation allows using substrates which are unsuitable for other purposes [5], and which can be used, after mushrooms are harvested, as protein additives to feed for livestock or as excellent organic fertilisers [6,7].

Scientists predict that in the future, 2/3 of people's protein requirement will be covered by the industrial production of edible mushrooms. Even today, about 80 countries of the world cultivate *Agaricus bisporus*

(AB), *Pleurotus ostreatus* (PO), shiitake, sheathed woodtufts (*Kuehneromyces mutabilis*), velvet shanks (*Flammulina velutipes*), etc. [8,9]. This is due to the high palatability of mushrooms, their nutritional and biological value, and their therapeutic and prophylactic properties [10-11]. Used as food, mushrooms increase a person's immunity to various infections, in particular, to cancer [12-15].

The most widespread mushrooms cultivated under artificial conditions are AB and PO. These mushrooms increase the human body's radioresistance and immunity to various diseases caused by the Chernobyl disaster [12].

Mushrooms are perishable products, which rapidly lose their marketability. To slow down these unfavourable processes, they must be stored at low temperatures. The optimum storage temperature is considered to be within the range 0 to 2°C. However, in practice, manufacturers and trading networks do not always provide these conditions. So, it is important to determine how different storage temperatures determine the changes in the sensory characterisitcs of mushrooms, their natural loss, output of marketable products, and chemical composition. This will allow drawing conclusions how to use these products after storage.

Analysis of recent research and publications

When products are stored fresh, their biological stabilisation is one of the most difficult problems, because histolysis is but a natural physiological phenomenon. Mushrooms, like any living organism, gradually become old and die. So, storage of mushrooms is a stage of their life. It slows down their after-ripening and is directly related to the specific features that mushrooms have received in the course of growth and development [16]. Physical and physiological, and biochemical processes in mushrooms during storage has an effect on their quality. In a way, these processes continue the ones occurring in mushrooms during their growth. The only difference is that during growth, the mushrooms accumulate nutrients, but during storage, lose them.

Mushrooms are juicy products, because they contain about 90% of water. This high saturation of the tissues with water is responsible for the intensive metabolism during the storage period, in comparison with non-juicy objects of plant origin. Mushrooms lose a lot of moisture on evaporation, especially at low relative humidity of the air, because of the poor protection provided by the external tissues of mushrooms. Besides, the resistance of mushrooms to phytopathogenic microflora is relatively low, and they can be a friendly medium for development of microorganisms [17].

While stored and transported, mushrooms evaporate moisture and spend organic matter on respiration. As a result, products lose weight, which is called natural loss (NL). Much of NL is due to evaporation of moisture (65-90%) and because of spending organic matter through respiration (10–35%). This loss is inevitable with any conditions of storage and transportation [18-20].

High storage temperatures and the condition of products intensify their respiration. A high water content causes high activity of biochemical processes during storage [21].

The respiration intensity of fresh mushrooms is higher than that of apples, tomatoes, and other fruits, while their shelf life is minimal (compared with these fruits). This may be explained by biological features of their development and by the incompactness of their tissues and, accordingly, a high degree of aeration of the tissues with oxygen [22].

Evaporation of moisture depends on the degree of hydrophilicity of cellular colloids, the anatomical structure ,and the condition of the covering tissues. An example is green vegetables, in which vacuolar and cytoplasmic colloidal particles are almost incapable of holding water (mostly free) and lose it easily. Under these conditions, they wither, losing their freshness [23]. Similar processes occur in mushrooms, but with less intensity, due to the peculiarities of their structure. Mushrooms are a little higher in protein than vegetables are, and protein binds much more water than other dry matter (DM) do [24-26].

The intensity of evaporation and the amount of moisture lost do not only depend on its content, but also on the temperature and humidity of the ambient air. The higher the temperature and lower the humidity in the room where the products are stored, the more moisture they evaporate [27].

During storage, products release heat that tells on the degree of their heating. Long time storage at a low temperature (about 0°C) inhibits the intensity of cellular metabolism, slows down respiration, reduces the expenditure of storage materials, and inhibits the activity of microorganisms. Self-heating can occur when products are stored in a big layer. Heat released with respiration accumulates, which increases the temperature and thus, the activity of microorganisms. They consume oxygen, release carbon dioxide and a lot of heat. The increasing temperature of the products intensifies their respiration. Oxygen cannot reach the internal tissues of mushrooms, and they darken because polyphenol oxidase (tyrosinase) oxidises tyrosine to form dark-coloured melanin substances of [28]. The damaged tissues begin to rot.

Moistening of mushrooms is due to condensation of moisture after the warm air rising from inside the layer of products comes into contact with the cold air outside. To prevent formation of moisture droplets, it is necessary to reduce the layer of loading, cool the products to the optimum temperature and provide proper thermal insulation of the storage place [29].

Intense physiological processes in fresh mushrooms make their shelf life short. After this term is over, mushrooms sharply lose quality and can accumulate compounds harmful for people. Among these, there are carcinogenic substances, such as N-nitrosamines and their derivatives, which can cause tumours of different origin.

The preservation of mushrooms is largely influenced by the conditions of their cultivation. Sufficient moisture in the compost and covering mixture results in fruiting bodies with high turgor [30] that ensures their good keeping capacity. Mushrooms grown at the low-temperature have uniform growth rates, and their fruiting bodies are stored for a longer time [22].

Thus, AB and PO belong to juicy products with a short shelf life determined by the physiology of their growth and development, the structure of their fruiting bodies, their chemical composition, and the activity of biochemical processes. During storage, mushrooms intensively release moisture and heat, which can cause self-heating, moistening, changes in the chemical composition and development of harmful microflora.

There have been some investigations aimed at developing new technologies, establishing parameters and conditions that would allow preserving the quality and increasing the shelf life of fresh mushrooms. Thus, in [31], the authors determined how different storage temperatures effected on changes in the chemical parameters of AB. However, the researchers did not establish the complex effect of the temperature on the keeping capacity of products (organoleptic characteristics, natural loss, marketability).

Good results for extension of the shelf life of mushrooms were obtained by storing them using controlled atmosphere conditions (CAC), modified atmosphere packaging (MAP), modified humidity packaging (MHP) [32-34]. In the case of CAC, the product was stored in a refrigerator, where an atmospheric composition, with certain relative humidity and O_2 and CO_2 concentration, was created and kept constant throughout storage. The main disadvantage of this technology is the significant cost of equipment and its maintenance.

MAP is a method of storage when a fresh product is packaged in a special polymer film that has different permeability to gases. Thus, a changed atmosphere is created by respiratory exchange, namely, by consuming oxygen and releasing carbon dioxide [35]. However, many polymer films used for packaging have lower vapour permeability as compared with the respiration rate of mushrooms. This causes water condensation and development of microflora. To prevent it, the package is perforated [36], and special water-absorbing compounds are used [37]. The disadvantage of MAP and MHP is the need to use special packaging materials, special food-grade water-absorbing substances, and special packaging equipment. All this significantly increases the cost of production.

The complex effect of temperature parameters and duration of storage on the NL of mushrooms, changes in their marketability and chemical composition has not been studied yet.

The purpose of the research is establishing the optimal storage temperature of AB and PO mushrooms. To achieve the purpose, the following **objectives** were formulated:

– to investigate the how different temperatures determine the level of NL of mushrooms;

– to establish the output of marketable mushrooms at different temperature parameters and durations of storage;

– to determine the changes in the chemical parameters of mushrooms after storage for 6 days at different temperatures.

Research materials and methods

Mushrooms to be stored were grown in cultivation-tailored facilities by the intensive technology [38] appropriate for certain species and strains. The research used the mycelium of AB (strain IBK-25) and of PO (strain NK-35) from the collection of M.G.Kholodny Institute of Botany (National Academy of Sciences of Ukraine). These strains are widespread, all-purpose, and suitable for year-round cultivation.

The mushrooms of the first and second flushes were used in the experiments. To this end, average samples of AB and PO mushrooms were taken at the peak of a flush, according to TU U 01.1-2582400336-001-2004. The peak of the first and second flush was on the third day for both mushrooms species. Between the flushes, AB restored its mycelium in 4-6 days, and PO in 8–12 days. The process of storage of these mushrooms was studies following the instructions in *Methods of research in vegetable and melon cultivation* [39].

Mushrooms were stored at cooling chambers КХ–6Ю, with the working volume 6 m^3, equipped with electric lighting and temperature and humidity controllers.

The mushrooms put in storage two hours after harvesting. They were hand-harvested and immediately placed in plastic boxes, with the capacity 5kg, in which they were then stored. The boxes were filled with mushrooms carefully, with no shaking nor ramming the contents down. The thickness of a layer did not exceed 3–4 heights of a mushroom. The weight of a sample in each box was 3–5 kg. Before storage, the experimental samples were numbered, weighed, and labelled indicating the date of the start of storage, the weight, the temperature parameters, and the replication variant of the temperature parameters.

To determine the chemical characteristics, polymer nets with mushroom samples weighing 0.5 kg each were placed over the contents of the boxes, not more than one net in a box, which was done in triplicate.

Based on our objectives, the review of literature, and our previous studies, in this research, we chose the temperatures of storing the mushrooms -1, +1, +3, and +5°C and the storage duration 6 days. The relative humidity in the storage chambers was 90±1%. The reference was the mushrooms kept at +1°C according to DSTU ISO 7561-2001. The scheme of the experiment is shown in Fig. 1.

Changes in the mushroom quality after 6 days of storage were determined by marketability, sensory, and chemical parameters.

The level of NL was determined by the method of fixed samples. The samples were weighed before storage and on each day of storage. The NL was calculated by the formula:

$$NL = \frac{A - B}{A} \cdot 100\%, \qquad (1)$$

where NL is the level of NL, g;

A is the weight of the sample before storage, g;

B is the weight of the sample on each day of storage, g.

The marketability of the mushrooms was estimated visually (by the appearance, colour, smell, surface condition, integrity, consistency).

The density of the carpophore of the AB before and after storage was determined by the formula:

$$D = \frac{m_c}{d_h}, \qquad (2)$$

where D is the density of the carpophore, g/cm;

m_c is the weight of the carpophore, g;

d_h is the diameter of mushroom cap, cm.

The DM was determined according to DSTU 7804:2015, the protein nitrogen (PN) according to DSTU 4923:2008, and the amount of ascorbic acid (AA) according to DSTU 7803:2015.

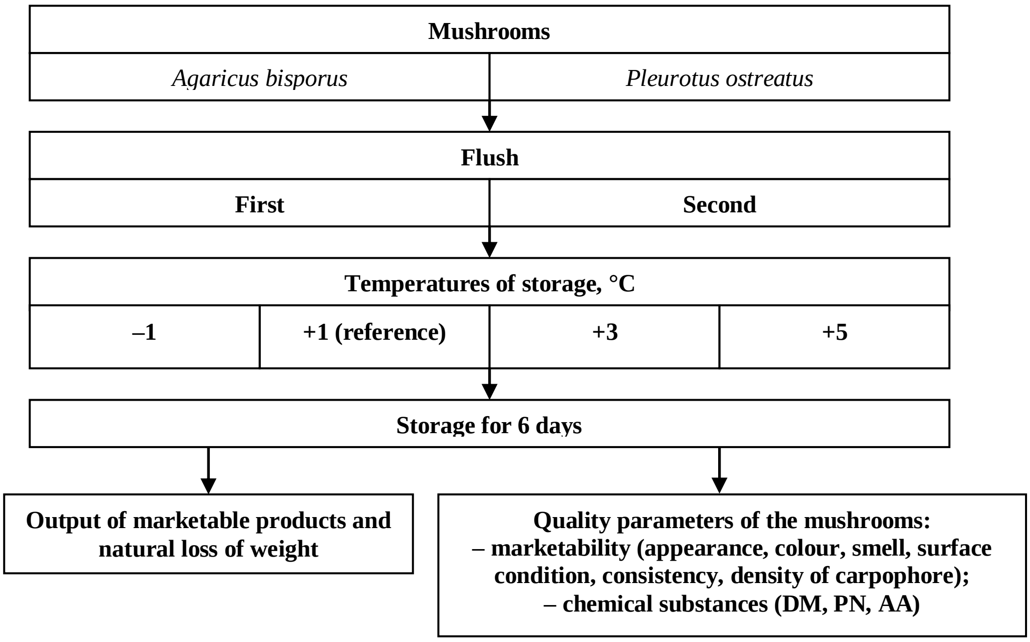

Fig. 1. Scheme of the experiment to determine the influence of storage conditions on the quality of mushrooms

Results of the research and their discussion

The factor that limits scaling up production of mushrooms is their short shelf life. These products are quite difficult to preserve, because they require specific conditions, technologies, and certain types of warehouses equipped with condition monitoring and control systems. Besides, to sell mushrooms fresh, it is necessary to provide proper postharvest handling, sorting, and packaging.

As can be seen in Fig. 2, the AB mushrooms were best stored at 1°C (reference). The fruiting bodies met the requirements to standard products. They remained whole and solid, and changed their colour and smell but slightly. Mushrooms with caps opened or partially opened were few, not more than 3%. With higher storage temperatures, the mushrooms were losing their marketability. Their skin darkened, they lost their elasticity, there appeared more mushrooms with caps open and ones damaged by bacterial spots. At, 5°C, spots of mould and the smell characteristic of aging mushrooms were registered. These mushrooms can no longer be sold fresh, but are suitable for processing after sorting.

In AB mushrooms stored at -1ºC, all fruiting bodies froze partially or completely. This must be due to their high moisture (90–93%) [40] and low sugar content (about 2%) [41]. The structure of the tissues destroyed and did not restore after defrosting the products. The fruiting bodies became dark-coloured, slippery, and soft. Such mushrooms are good for nothing, that is why storage at -1°C was not considered in the further research.

For the PO, too, the best storage temperature was 1°C (reference) (Fig. 3). The mushrooms complied with the standard: whole, elastic, without significant changes in colour and smell. The marketable quality of PO was lost with an increase in the storage temperature. They became less elastic, there appeared more fruiting bodies with cracked edges, and their colour changed from dark grey to grey and beige. At 5°C, white web-like filaments appeared on the mycelium. This is characteristic of PO and indicates the further growth of mushrooms. Such mushrooms cannot be sold fresh, but are suitable for processing.

Storage of the OP mushrooms at -1°C led to their partial freezing. After defrosting, their fruiting bodies lost their marketability, but did not completely lose their taste and structure. This must be due to a high content of DM (9.4-10.3%) and chitin, and to their cell structure [42]. It should be considered whether mushrooms of this quality can be used for processing.

Mushrooms are juicy products that contain a lot of free moisture. That is why, when stored, they lose some of their weight. The weight loss in AB and PO during storage includes loss of DM and moisture.

The NL in the AB after 6 days of storage, depending on the temperatures and the flush, ranged 4.9–7.2% (Tables 1, 2).

The most intensive loss of weight was on the first 4 days. This was because after the mushrooms were cut, the processes of spore maturation continued and the amount of sugars decreased, as they were spent on respiration (which becomes more intense before the fruiting body starts ageing). The dynamics of the loss depended both on the storage temperature and on the flush. Lower storage temperatures inhibited physiological and biochemical processes in the mushroom tissues, which reduced the loss from 6.9-7.2% (5°C) to 4.9-5.1% (1°C), depending on the flush. In the second flush the NL was bigger due to the lower quality of the mushrooms. They were worse than the first flush products, because the compost had already been exhausted to some extent. So, the second flush mushrooms have a less firm carpophore and are lower in DM, in particular, proteins that can bind and retain moisture.

After 6 days of storing AB of the strain IBK-25 at 1°C, the output of marketable fruiting bodies was 92.6–93.8% depending on the flush; for those stored at 3°C, it was 89.2–89.8%, and at 5 °C, it was 73.5–75.4% (Table 2). The decrease in marketable fruits after the storage temperature increased resulted from the intensification of respiration, ageing, and loss of moisture observed at higher temperature parameters, which leads to a larger output of nonmarketable products. AB mushrooms are nonmarketable when their caps are partially open, more than a quarter of their outer surface darkens, they are damaged by bacterial spots and cobweb mould. Their quantities, depending on the flush, were 1.8–2.3% at 1°C, 4.5–5.0% at 3°C, and 17.7–19.3% at 5°C.

–1°C 1°C (reference) 3°C

Fig. 2. AB (strain IBK-25) after 6 days of storage at different temperatures

–1°C 1°C (reference) 3°C 5°C

Fig. 3. PO (strain NK-35) after 6 days of storage at different temperatures

The densest carpophores (5.34g/cm) were observed in the mushrooms of the first flush after storage at 1°C due to their higher quality and more DM. The density of the carpophore decreases when the storage temperature increases due to the loss of moisture and the transformation of biochemical substances.

Fruiting bodies of PO have a large area of moisture evaporation, which results in higher NL during storage, as compared with AB. The maximum NL of weight was on the first 3 days of storage (3.7–5.3%, depending on the temperature) (Table 3).

The NL in the PO stored at 5°C began to increase on the 5th day, which is due to the loss of DM involved in preparing the fruiting body to release spores. The total NL during storage of the PO was 5.4–9.5% (Table 4).

Table 1 – Dynamics of NL in AB of the strain IBK-25 during storage at different temperatures, % (n=3, p≤0.05)

Temperature of storage, °C	Duration of storage, days					
	1	2	3	4	5	6
First flush						
+1 (reference)	0.8	1.9	2.7	4.0	4.7	4.9
+3	1.7	2.3	3.3	4.3	5.4	5.7
+5	1.8	2.4	3.7	5.0	5.7	6.9
Second flush						
+1 (reference)	0.9	1.8	2.8	3.8	5.0	5.1
+3	1.0	2.0	3.1	4.1	5.4	5.8
+5	1.2	2.2	3.4	5.1	5.9	7.2

Table 2 – Effect of the temperature parameters on the preservation of the fruiting bodies of AB of the strain IBK-25 (n=3, p≤0.05)

Temperature of storage, °C	NL of weight, %	Output of nonmarketable mushrooms, %	Output of marketable mushrooms, %	Density of the carpophore, g/cm
First flush				
+1 (reference)	4.9	1.8	93.3	5.34
+3	5.7	4.5	89.8	5.28
+5	6.9	17.7	75.4	5.21
Second flush				
+1 (reference)	5.1	2.3	92.6	5.31
+3	5.8	5.0	89.2	5.28
+5	7.2	19.3	73.5	5.20

Table 3 – Dynamics of the NL in PO of the strain NK-35 during storage at different temperatures, % (n=3, p≤0.05)

Temperature of storage, °C	Duration of storage, days					
	1	2	3	4	5	6
First flush						
-1	1.4	2.3	3.7	4.4	4.8	5.4
+1 (reference)	1.5	2.9	4.1	4.8	5.1	5.7
+3	1.8	3.6	4.5	5.1	5.5	6.3
+5	2.1	3.9	4.9	5.6	7.3	9.1
Second flush						
-1	1.5	2.2	4.0	5.0	5.5	5.9
+1 (reference)	1.6	2.4	4.2	4.6	5.4	6.1
+3	1.8	3.5	4.8	5.3	6.0	6.8
+5	2.3	3.6	5.3	5.8	7.7	9.5

Table 4 – Effect of the temperature parameters on the preservation of the fruiting bodies of PO of strain NK-35 (n=3, p≤0.05)

Temperature of storage, °C	NL of weight, %	Output of nonmarketable mushrooms, %	Output of marketable mushrooms, %
First flush			
-1	5.4	75.2	19.9
+1 (reference)	5.7	0.5	93.8
+3	6.3	3.1	90.6
+5	9.1	8.7	82.2
Second flush			
-1	5.9	78.2	15.9
+1 (reference)	6.1	1.1	92.8
+3	6.8	3.9	89.3
+5	9.5	9.9	80.6

The lowest NL was observed in mushrooms of the first flush at the storage temperature -1°C, and the largest in those of the second flush at 5°C. This may be because a temperature decrease slows down physiological (respiration) and biochemical processes in living objects.

At -1°C, fruiting bodies of PO become off-standard due to freezing. Not all fruiting bodies freeze, though (75.2–78.2%). This must be because PO gives out more heat and is higher in DM than AB. Storage of the first flush PO results in fewer nonmarketable (frozen) fruits, which may be due to more DM and PN in the first flush mushrooms.

The fruiting bodies of PO are off-standard when there is significant cracking of the cap, the mushrooms dry up, and white hyphae of the mycelium appear. In the reference, the quantity of off-standard fruiting bodies was the smallest (0.5–1.1%). When the temperature was raised to 3°C, there were more of them, 3.1–3.9%, and at 5°C, their quantity grew up to 8.7–9.9%, depending on the flush. The output of fruiting bodies was 15.9–19.9% at -1°C, 92.8–93.8% at 1°C, 89.3–90.6% at 3°C, and 80.6–82.2% at 5°C.

It has been noted above that during storage, the PO had greater NL than the AB due to a larger evaporation area, but there were fewer nonmarketable fruiting bodies (8.7–9.9%, while at 5°C, there were 17.7–19.3% of them). In general, at 1°C, the output of marketable products in both mushroom species was about the same, but with a higher storage temperature, the output of standard fruiting bodies of the PO was larger.

The storage of mushrooms was accompanied by some changes in their chemical composition (Tables 5, 6).

The research results indicate that after mushrooms are stored for 6 days, the amount of DM and vitamin C decreases, while that of PN decreases, too, or remains almost unchanged. Thus, in the first flush AB stored at 1°C, the DM at the beginning of storage was 9.4%, and at the end, it was 8.9%, and the AA was 5.6 and 5.1 mg% respectively. The PN did not change and was 3.0%. Under the same conditions, the DM in the PO changed from 10.3 to 9.5%, the AA from 9.8 to 9.0 mg%, and the PN did not change and remained 3.0% (Table 6).

As the storage temperature increases, the loss of DM, PN, and AA increases, too. Thus, in the first flush AB stored at 5°C, the DM decreased from 9.4% to 8.0%, the AA from 5.6 to 4.5 mg%, the PN from 3.0 to 2.9% (Table 5). Raising the storage temperature of the first flush PO to 5°C, too, led to a bigger loss of chemicals: the DM decreased from 9.4 to 7.7%, the AA from 9.6 to 7.6 mg%, and the PN from 2.8 to 2.6% (Table 6).

Table 5 – Effect of the temperature parameters of storage on changes in the chemical composition of the fruiting bodies of AB of the strain IBK-25 (n=3, p≤0.05)

Temperature of storage, °C	DM, %		PN, %		AA, mg%	
	Before storage	**After storage**	**Before storage**	**After storage**	**Before storage**	**After storage**
First flush						
+1 (reference)	9.4	8.9	3.0	3.0	5.6	5.1
+3	9.4	8.5	3.0	3.0	5.6	4.9
+5	9.4	8.0	3.0	2.8	5.6	4.5
Second flush						
+1 (reference)	8.6	7.8	2.9	2.9	5.4	5.0
+3	8.6	7.4	2.9	2.8	5.4	4.4
+5	8.6	7.1	2.9	2.7	5.4	4.0

Table 6 – Effect of the temperature parameters of storage on changes in the chemical composition of the fruiting bodies of PO of the strain NK-35, % (n=3, p≤0.05)

Temperature of storage, °C	DM, %		PN, %		AA, mg%	
	before storage	**after storage**	**before storage**	**after storage**	**before storage**	**after storage**
First flush						
-1	10.3	9.3	3.0	2.9	9.8	9.4
+1 (reference)	10.3	9.5	3.0	3.0	9.8	9.0
+3	10.3	9.4	3.0	3.0	9.8	8.7
+5	10.3	9.0	3.0	2.8	9.8	8.4
Second flush						
-1	9.4	8.8	2.8	2.7	9.6	8.8
+1 (reference)	9.4	8.5	2.8	2.8	9.6	8.5
+3	9.4	8.3	2.8	2.7	9.6	8.0
+5	9.4	7.7	2.8	2.6	9.6	7.6

Changes in the chemical composition of both species of mushrooms of the second flush were similar, only the the amounts of substances were different. The second flush fruits accumulated less DM, AA, PN, and the higher temperatures caused a greater loss of these substances during storage. Of all the chemicals in the mushrooms studied, the quantity of PN was the most stable.

It should be noted that during the growing season, the PO accumulated more DM and AA, that is why it contained more of them after storage at different temperatures. The PN content in both species was almost the same: 2.8–3.0%, and it practically did not change during storage.

Conclusion

As a result of the research, it has been found that the lowest NL in AB (4.9–5.1%) and in PO (5.7–6.1%) is observed at the storage temperature 1°C (depending on the flush), while the maximum NL observed is 5.7–7.2% and 6.3–9.5% respectively, depending on the storage temperature and the flush.

It has been found that the highest output of marketable products for both mushroom species stored for 6 days under controlled conditions was at the storage temperature 1°C: 92.6–93.3% for AB and 92.8–93.8% for PO. The lowest outputs observed were 73.5–89.8% and 80.6–90.6% respectively (depending on the temperature and the flush).

It has been determined that higher temperatures of storing mushrooms resulted in greater changes in their chemical composition. In the AB, the maximum changes were observed at 5°C: the quantity of DM changed from 9.4% to 8.0%, that of AA from 5.6 to 4.5mg%, and that of PN from 3.0 to 2.8%. The smallest changes were observed at 1°C: the DM changed from 8.9 to 9.4%, the AA from 5.1 to 5.6mg%, and the PN did not change. The changes in the chemical composition of the PO were similar.

Thus, the research results allow us to recommend 1°C as the optimal temperature when storing AB and PO for 6 days, since this temperature ensures preservation of their sensory, commercial (marketability), and chemical parameters.

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ЗМІНА ПОКАЗНИКІВ ЯКОСТІ ГРИБІВ ЗАЛЕЖНО ВІД ТРИВАЛОСТІ ТА УМОВ ЗБЕРІГАННЯ

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Анотація. Представлено результати досліджень щодо впливу умов та тривалості зберігання на зміну показників якості грибів печериці двоспорової (*Agaricus bisporus*) штаму ІБК-25 та гливи звичайної (*Pleurotus ostreatus*) штаму НК-35. Зміни якості грибів визначали перед закладанням на зберігання та після 6 діб за органолептичними, товарними та хімічними показниками. Температура зберігання становила мінус 1, 1, 3 та 5°С, відносна вологість повітря - 90±1%. Якість продукції оцінювали за зовнішнім виглядом, величиною природних втрат, виходом товарних грибів і хімічними показниками (сухі речовини, білковий азот, вміст аскорбінової кислоти). Результати візуальних спостережень свідчать, що впродовж 6 діб гриби краще зберігалися за температури 1°С. За температури мінус 1°С печериця підмерзала і після розморожування не була придатна для використання, а глива відновлювала свою структуру і після сортування її можна було переробляти. За 6 діб зберігання за температури 3°С, залежно від хвилі плодоношення, вихід товарних печериць зменшився на 3,4 та 3,5%, гливи – на 3,4 та 3,8%, порівняно з контролем; за 5°С – у печериці на 19,2 і 20,6% та у гливи на 12,4 і 13,1%, відповідно. За 6 діб глива мала більші природні втрати, ніж печериця, що обумовлено більшою площею випаровування, але меншу кількість нестандартних грибів 8,7–9,9% проти 17,7–19,3% при 5°С. Вихід товарної продукції за температури 1ºС в обох видів грибів був приблизно однаковим, але при її збільшенні до 5ºС у гливи він був більшим на 9,0-9,4%. При зберіганні печериці впродовж 6 діб змінився вміст

деяких хімічних речовин: зменшилася суха речовина (на 5,3–17,4%), вітамін С (на 7,4–25,9%) та майже не змінився білковий азот. Аналогічні тенденції були характерні і для гливи звичайної. Тобто, в результаті проведених досліджень рекомендуємо, як оптимальний температурний режим зберігання для грибів печериця двоспорова та глива звичайна – 1°С, який забезпечує збереження їх органолептичних, товарних та хімічних показників.

Ключові слова: гриби, печериця двоспорова, глива звичайна, тривалість зберігання, товарність, природні втрати, якість.

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