

Influence of the substrate composition on the yield and nutritional value of the fruiting bodies of the edible mushrooms *Pleurotus citrinopileatus* and *Cyclocybe aegerita*

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Purpose. To reveal the influence of the substrate compositions on technical indicators and the chemical composition of the fruiting bodies of the golden oyster mushroom and poplar mushroom. **Methods.** The experimental design included cultivation of two species of wood-decay fungi *Pleurotus citrinopileatus* Singer (strain 2161 IVK) and *Cyclocybe aegerita* (V.Brig.) Vizzini (strain 2230 IVK) on three variants of substrate composition. Laboratory, laboratory-production methods for evaluating the effectiveness of growing technology, chemical composition of the obtained raw materials, statistical methods of analysis were applied. **Results.** The structure and composition of substrates affect the technological characteristics of the culture, physical and chemical properties of fruiting bodies. The shortest fruiting cycle of 35.2 ± 1.7 days was determined for *C. aegerita* under growing conditions on SC1 substrate which formula included «straw, husks, pellet, rapeseed, corn, and CaCO_3 » in the ratio of 30: 40: 70: 20: 20: 1. The highest yield (170.5 ± 15.2 g per 1 kg of substrate) in the experiment was determined for *P. citrinopileatus* on the SC1 substrate composed of «straw / pellets / rapeseed / corn / CaCO_3 » in the ratio 40: 90: 20: 25: 1. Fruiting bodies of *P. citrinopileatus* obtained from the SC3 substrate composed of «pellets / rapeseed / corn / CaCO_3 » in the ratio 60: 110: 20: 30: 1 had the highest protein content – $22.47 \pm 0.19\%$, and fruiting bodies from the SC1 substrate had the least amount of proteins – $17.38 \pm 2.60\%$. Fruiting bodies of *C. aegerita* contained more lipids than those of *P. citrinopileatus*, but the factor of the influence of the substrate composition on the total amount of lipids for some cultivars was insignificant. The largest amount of endopolysaccharides was isolated from the fruiting bodies of *C. aegerita* ($6.81 \pm 0.41\%$) cultivated on SC3 substrate, and the smallest in the SC1 variant ($1.38 \pm 0.25\%$). The content of endopolysaccharides in the fruiting bodies of *P. citrinopileatus* had less variability from 2.54 ± 0.54 (SC3) to $4.72 \pm 0.61\%$ (SC1). **Conclusion.** Substrate compositions significantly affect the biological efficiency of cultivars and the content of nutrients in fruiting bodies of the studied species. The obtained results enable producers of mushrooms to predict the production efficiency and quality of grown mushrooms in accordance with the use of available raw materials.

Keywords: cultivation of mushrooms; golden oyster mushroom; poplar mushroom; biological effectiveness; chemical composition.

Introduction

Exotic mushrooms have already become an integral part of functional diets due to the con-

tent of bioactive substances with proven nutritional and medicinal value. In Asian countries, which are leaders in the production and consumption of mushrooms, wood-decay fungi are preferred, and shiitake and various species of oyster mushrooms are popular: oyster mushroom, king oyster mushroom, Lung Oyster and others. But in recent years, the demand for golden oyster mushroom *Pleurotus citrinopileatus* Singer («Gold mushroom») and poplar mushroom *Cyclocybe aegerita* (V.Brig.) Vizzini, known in Europe and America as «velvet pioppini» has been growing rapidly [1, 2].

The golden oyster mushroom is appreciated for its bright, rich yellow color of the cap and the

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specific light and pleasant aroma of seafood, which appears after a short thermal treatment [3]. Fruiting bodies of this fungus contain $22.10 \pm 2.03\%$ of protein, and in the biomass obtained by submerged cultivation, protein content reaches $36.2 \pm 1.2\%$ [3, 4]. According to published data [5], the amount of lipids varies from 1.32 to 3.37%, but does not exceed 5%. Such interesting dietary features of *P. citrinopileatus* are complemented by the content of substances with high medicinal potential, for example, the nonlectin glycoprotein (PCP-3A) found in fresh fruiting bodies [6]. Researchers [7, 8] emphasize the high antitumor ability of glycoproteins of this species of oyster mushroom, as well as their antioxidant and hypoglycemic properties.

The poplar mushroom is firm in texture and keeps the shape and structure of fruiting bodies after boiling; mushrooms remain dense and crisp, retaining the dark color of the cap [9]. But in addition to high nutrition indicators, the fruiting bodies of poplar mushroom contain unique ceramides with proven antitumor potential [10]. The antioxidant properties of the extracted polysaccharides and their ability to stabilize skin collagen were discovered. That reveals the prospects for the use of these substances as natural agents or food additives in gerontological practice and for combating age-related complications [11].

Bright and rich colors of fruiting bodies of golden oyster mushrooms and poplar mushrooms always attract consumers. On the other hand, these species have repeatedly proven nutritional and medicinal value, which makes them an integral part of health food in Asia and Europe [1–4]. The price of these mushrooms is an order of magnitude higher in comparison with the already known button mushroom champignons and oyster mushrooms, what determines the interest of mushroom producers in growing these species. The domestic adaptation of the known regulations for the cultivation of golden oyster mushrooms and poplar mushroom is significantly slowed down in the absence of information about the possibility of using available agricultural by-products and its effect on the quality of mushroom products. Researchers emphasize the significant influence of substrate compositions and methods of their preparation on the technical indicators of growing mushroom culture, on the content of organic and mineral substances in mushrooms, which, accordingly, changes their taste and aroma [3, 4]. In particular, scientists from Kenya determined that the formation of *P. citrinopileatus* primordia began on the 13th day

from the moment of inoculation on bean straw substrate, while on the sawdust substrate – on the 31st; the biological efficiency of the culture was 149% from the bean straw substrate and decreased to less than 1% when sawdust was used [4]. Enrichment of wheat straw substrates with poultry litter and millet grains allowed researchers from the United States to increase the biological efficiency of *C. aegerita* cultivation fivefold. In the same experiment, the optimal ratio of 70 : 10 : 20 components in the substrate formula «straw / litter / millet» contributed to the increased protein content in the fruiting bodies of *C. aegerita* to 37.6%, while on the substrate made of wheat straw this indicator was 27.1% [12–14].

The main components of substrates for artificial cultivation of *P. citrinopileatus* and *C. aegerita* are cereal straw and sunflower husk, which cost increases annually and significantly depends on logistics. Previous studies showed the possibility of using fuel pellets made from sunflower husks to increase the efficiency of growing wood-decay fungi [15]. But the high density of such raw materials leads to a decrease in the aeration characteristics of the substrates, which can affect the physiological and biochemical parameters of the culture.

The purpose of the study is to reveal the effect of substrate composition content on the technical and chemical parameters of fresh fruiting bodies of golden oyster mushroom (*P. citrinopileatus*) and poplar mushroom (*C. aegerita*).

Materials and methods

The cultures of the studied species – strains of *P. citrinopileatus* 2161 IVK and *C. aegerita* 2230 IVK, were obtained from the collection of cap mushrooms cultures of the M. G. Kholodny Institute of Botany and maintained on a nutrient medium of the following composition: 20 g agar-agar, 20 g malt-dextrose, 2 g dry yeast extract, up to 1 liter water. The pH of the medium was adjusted to 6.7 ± 0.2 with 0.1N KOH solution and sterilized for 35 min at 121 °C [16].

For the manufacture of substrate compositions, the following components were used: local raw materials – barley straw and sunflower husks crushed to 5–7 mm, as well as fuel pellets from husk. The composition of the substrate compositions was calculated so as to achieve a carbon to nitrogen (C : N) ratio of 20 : 1, in accordance with published data [17]. Rapeseed was added to the formula to provide the required lipid content [18]. Also, the formulas of the compositions were calculated so as to achieve the optimal values of moisture indicators (63–65%) and substrate density

from 350 to 550 kg/m [15]. The required water content was calculated taking into account the

initial moisture content of the raw material (Table 1).

Table 1
The ratio of the components of the substrate compositions (SC) by weight (kg)

| Composition code | Straw | Husks | Pellets | Rapeseed | Corn | Chalk (CaCO ₃) | Water |
|------------------|-------|-------|---------|----------|------|----------------------------|-------|
| SC1 | 30 | 40 | 70 | 20 | 20 | 1 | 263 |
| SC2 | 40 | 0 | 90 | 20 | 25 | 1 | 325 |
| SC3 | 0 | 60 | 110 | 20 | 30 | 1 | 288 |
| Moisture, % | 11.5 | 8.8 | 7.5 | 10.5 | 7.8 | 12.3 | 100 |

Straw, husks and rape plant seeds were soaked with an excess of cold water for 8–10 hours. The moistened raw materials were put into mixing containers. Pallets were prepared separately: warm water (30–40 °C) was added, the moist components were mixed adding ground corn and chalk. The finished compositions were packed in polypropylene bags 580 × 480 mm, with four filters in the upper part measuring 20 × 480 mm, 3250 ± 50 g each. The substrates were sterilized in an industrial autoclave at 121 ± 3 °C for 120 min. The substrates, cooled to a temperature of 26 ± 1 °C, were inoculated under aseptic conditions with mycelium-covered cereal at 3% by weight (100 ± 15 g per bag). For each variant of the experiment, 30 bags were made. Substrate samples were taken after inoculation (from five bags of 50 g each) and mixed. The averaged sample was used for analysis.

The density of the substrate was determined by the formula:

$$\rho = m / V,$$

where ρ – density of the substrate, kg/m³; m – mass of the substrate, kg; V – volume of a unit of the substrate, m³.

The volume of the substrate block was determined by the formula:

$$V = \pi \times a \times b \times h,$$

where π – 3.14; a – the semi-major axis of the package after installation on the shelf had the shape of an ellipse, m; b – semi-minor axis, m; h – substrate height, m.

The moisture content of plant raw materials and manufactured substrates was determined gravimetrically at a temperature of 102 ± 1 °C, but the samples of fruiting bodies were first dried at a temperature of 45 °C, taking into account the characteristics of the mushroom raw material, and then dried to an absolutely dry mass at 92 ± 2 °C.

The concentration of hydrogen ions (pH) of the substrate was determined according to national standard DSTU ISO 10390: 2007 Soil quality. Determination of pH (ISO 10390: 2007, IDT).

The ash content was determined as follows: 3 g of absolutely dry powder of the fruiting

body were weighed in ceramic crucibles of known weight, burned in a muffle furnace at a temperature of 550 ± 10 °C for three hours, and the samples were cooled in a desiccator. The ratio of the residual mass to the original mass of the sample in percent was calculated.

The total nitrogen content was determined by the chloramine method according to Pochinok.

The C/N ratio was determined by the formula $C/N = 0.5 (100 - a) / N$, where a – the ash content, %; 0.5 – coefficient of carbohydrate content, adjusted for the biochemical characteristics of raw materials; N – the content of total nitrogen in the substrate [20].

The analysis of the technical parameters of the substrates and the chemical analysis of the fungi were carried out in triple repetition for each cultivation cycle.

The substrates were incubated at a temperature of 23 ± 3 °C and a humidity of 65% indoors. Lighting was used only to control the development of a culture.

Fruiting was initiated from the 20th day. The packages were placed in a growing chamber with appropriate microclimatic conditions: air temperature 14 ± 1 °C, relative air humidity 91 ± 5%; carbon dioxide content 1250 ± 150 ppm (0.12%). Illumination was maintained at 150–200 lux for 8 ± 1 hour per day. Taking into account the different level of shelves on racks regarding the floor and the possible difference in microclimatic conditions, the packages were installed randomly. Two 100 ± 20 mm cuts were made on the bags with *P. citrinopileatus* culture, but the substrate was not freed from the film. On the bags with the *C. aegerita* culture, a cut was made in the upper part and a polypropylene film was peeked back to the side (Fig. 1). The crop was harvested at the stage of technical maturity before the onset of sporulation.

Fresh fruiting bodies for biochemical analysis were collected from different blocks in accordance with the variant of the experiment, dried at a temperature of 55 ± 3 °C for 8–10 hours and ground into flour. Before analysis, the sample was additionally dried at a temperature of 102 ± 2 °C and cooled in a desiccator.

The moisture content, the amount of total nitrogen and ash were determined by the above methods in triplicate repetition. Lipid content was determined by extraction of mushroom samples (absolutely dry weight) in petroleum ether as a solvent using a Soxhlet extractor.

The total nitrogen content per crude protein content was calculated using a coefficient of 4.38 in terms of the amount digested in the human body [16].



Fig. 1. Types of holes on polypropylene bags for fruiting stimulation:

- a) two cuts 100 ± 20 mm for *P. citrinopileatus*;
b) one large incision for *S. aegerita*

Endopolysaccharides (endoPS) were extracted from dry matter according to the following procedure: 2 g of fruiting bodies powder were added to 10 ml of distilled water and thoroughly mixed; for 16 hours kept in an oven at a temperature of 98 ± 0.1 °C; the obtained extract was added with 96% ethyl alcohol in a ratio of 1 : 2 (by volume) to precipitate polysaccharides and settled for 24 hours at a temperature of 4 °C. The precipitate was separated by centrifugation at 5000 RPM for 25 minutes. The precipitate was dissolved by adding 20–30 ml of hot deionized water (90 ± 1 °C). The suspended endopolysaccharide fraction was dried at 60 °C

for 8 hours. The amount of endopolysaccharides in dry matter was determined gravimetrically and calculated by the formula: *weight of endopolysaccharide / weight of sample* × 100% [19].

The percentage of carbohydrates, excluding endopolysaccharides, was calculated using the formula: *100 – the amount of proteins (%) – the amount of lipids (%) – the amount of ash elements (%) – the amount of endopolysaccharides (%)*. The C/N ratio in the substrate was determined by the formula:

$$C/N = 0.52 (100 - a) / N,$$

where *a* – ash content, %; 0.52 – averaged coefficient of carbon content; *N* – total nitrogen content, % [20].

The yield from each separate bag was calculated by the ratio of the mass of the harvested mushrooms in grams per kilogram of the prepared substrate mass.

The biological efficiency (BE) of cultivars was calculated using the formula:

$$BE = \frac{M_{fb}}{M_{dm}} \times 100 \%$$

where M_{fb} – mass of raw fruit bodies; M_{dm} – mass of the substrate dry matter [21].

Statistical analysis of the obtained results was carried out using the Microsoft Office Excel 2016 MSO package and the built-in QI Macros 2020 program. One and two-factor ANOVA analysis was performed («a» is the highest indicator in the experiment), to compare the mean in the groups, the U-test (Mann–Whitney). The smallest significant difference was found using the significance level = 0.05.

Results and discussion

Based on the results of the analysis of the content of the prepared substrate compositions, the differences in the indicators of the content of ash elements and density were determined (Table 2).

In SC1 and SC2 substrates, which included straw, high ash content was determined in comparison with SC3, where only sunflower waste was used. The latter corresponds to the literature data on the composition of raw materials [22]. Also, the SC3 substrate significantly differed from others in terms of density (568 ± 21 kg/m³), which is associated with the absence of a sufficiently large fraction of straw. The indicators of moisture content and the content of the main nutrients in the calculated compositions did not differ, which indicates the possibility of theoretical calculation of the substrate formula based on the results of the analysis of raw materials. According to the

Table 2

**Characteristic of substrate compositions in the experiment
(mean \pm standard error)**

| Code | Moisture (%) | Total nitrogen (%) | Ash (%) | C/N ratio | Density (kg/m ³) |
|---------------------|----------------|--------------------|----------------|------------------|------------------------------|
| SC1 | 63.4 \pm 1.8 | 2.25 \pm 0.21 | 4.6a \pm 0.4 | 21.2 \pm 0.8/1 | 337b \pm 29 |
| SC2 | 65.9 \pm 1.7 | 2.38 \pm 0.15 | 4.8a \pm 0.7 | 20.0 \pm 1.3/1 | 315b \pm 42 |
| SC3 | 63.9 \pm 2.1 | 2.29 \pm 0.29 | 3.6b \pm 0.5 | 21.1 \pm 1.0/1 | 568a \pm 21 |
| LSD _{0.05} | 1.9 | 0.25 | 0.93 | 1.7 | 75 |

results of statistical analysis, a significant effect of the substrate composition content on the term of vegetative development of crops in the substrate (its end was determined by

the date of the first primordia formation), as well as on the indicators of the total yield and biological efficiency of cultivars was proved (Table 3).

Table 3

**Indicators of cultivation of *C. aegerita* and *P. citrinopileatus*
(average over 3 growing cycles \pm standard error) (2019–2020)**

| Culture | SC | Primordia formation (day) | Harvesting (day) | Total yield (g/kg) | Biological efficiency (%) |
|---------------------------|----|---------------------------|--------------------|--------------------|---------------------------|
| <i>C. aegerita</i> | 1 | 25.3c \pm 1.45 | 35.22b \pm 1.66 | 122.7a \pm 23.1 | 31.46b \pm 5.92 |
| | 2 | 28.2b \pm 0.80 | 38.20ab \pm 1.36 | 123.3a \pm 22.7 | 35.27ab \pm 6.48 |
| | 3 | 29.8ab \pm 0.41 | 38.58ab \pm 0.35 | 132.1a \pm 11.5 | 33.87ab \pm 2.95 |
| <i>P. citrinopileatus</i> | 1 | 26.3bc \pm 1.62 | 41.18a \pm 2.43 | 167.5a \pm 27.2 | 42.95ab \pm 6.96 |
| | 2 | 24.8c \pm 1.02 | 40.00a \pm 2.51 | 170.5a \pm 15.2 | 48.71a \pm 4.35 |
| | 3 | 32.0a \pm 0.95 | 39.60ab \pm 1.25 | 45.5b \pm 4.6 | 11.66c \pm 1.18 |
| LSD _{0.05} | – | 3.2 | 4.51 | 58.9 | 15.22 |
| <i>p</i> | – | 0.001 | 0.156 | 0.013 | 0.007 |

The shortest terms of primordia formation in the experiment were recorded when *P. citrinopileatus* was grown on the SC2 substrate composition, and the longest, also for this culture, on the SC3 substrate (24.80 \pm 1.02 and 32.00 \pm 0.95 days, respectively).

The cultures colonized the substrates and began to form primordia at different times. The fastest development of *C. aegerita* was determined on SC1 substrate (25.33 \pm 1.45 days), while the *P. citrinopileatus* culture was more active on SC2 (24.80 \pm 1.02 days). It should be noted that primordia appeared on SC3 substrate in both cultures much later: *C. aegerita* on 29.84 \pm 0.41 day, and *P. citrinopileatus* on 32.00 \pm 0.95 day.

There was no significant difference between the end of the harvest for grown crops by two-factor analysis of ANOVA data ($p = 0.156$), but after comparing means of the groups by the Mann–Whitney U-Test method, a significantly longer duration of fruiting ($p < 0.05$) was determined for *P. citrinopileatus* culture. The shortest cycle in the experiment had *C. aegerita* culture grown on SC1 substrate (35.22 \pm 1.66 days).

The substrate composition significantly ($p = 0.013$) influenced the yield of the studied species. In the experiment, the largest mass of fruiting bodies was collected on *P. citrinopileatus* culture on SC1 and SC2 (167.5 \pm 27.2 and

170.5 \pm 15.2 g per 1 kg of substrate, respectively). The lowest yield in the experiment (45.5 \pm 4.6 g/kg) was also determined for this crop on SC3 substrate.

The overall yield of *C. aegerita* cultivar in the experiment (122.7 ... 132.1 g/kg) was lower than the known scientific data. For example, when using a composition of wheat straw, chicken litter and millet seeds in a ratio of 70 : 20 : 10, researchers received up to 770.5 \pm 118.4 g of fresh mushrooms from 5000 g of substrate [12]. But the results obtained in the experiment significantly exceed the yield indicators for *C. aegerita*, grown on birch sawdust (87 g/kg) [13]. The obtained indicators of *P. citrinopileatus* productivity confirm the results [4] with the definition of low efficiency of this species when using substrates with high density. Also, the yield indicators practically coincided when grown on similar plant residues: on straw – 109.6 g, sugar cane – 177.1 g.

According to the results of statistical analysis, a significant effect of the composition of the substrate on the biological efficiency (BE) of *P. citrinopileatus* culture ($p = 0.006$) was determined, while for *C. aegerita* culture, no significant difference was found in this indicator between the experimental options ($p = 0.877$). The highest BE in the experiment was obtained under the conditions of *P. citrinopileatus* cultiva-

tion on SC2 substrate ($48.71 \pm 4.35\%$), and the lowest ($11.66 \pm 1.18\%$) – on the SC3 substrate for the same culture. The BE index of *C. aegerita* in the experiment varied slightly from $31.46 \pm 5.92\%$ (SC1) to $35.27 \pm 6.48\%$ (SC2). It should be noted that the results of the analysis were higher compared to the indicators of BE of *C. aegerita*, obtained by American scien-

tists [12] when using substrates with a low ratio of carbon to nitrogen (C/N), where BE was $6.3 \pm 2.4\%$ for C/N = 13/1 and $9.4 \pm 4.1\%$ for C/N = 30/1. As a result of the analysis of the obtained data, a significant influence of substrates on the chemical composition of the fruiting bodies of the studied species was determined (Table 4).

Table 4

Chemical parameters of fruiting bodies of *C. aegerita* and *P. citrinopileatus* according to experimental variants

| Species | SC | Crude protein (%) | Lipids (%) | Endopolysaccharides (%) | Other polysaccharides (%) | Ash (%) | Dry matter (%) |
|---------------------------|----|--------------------|-------------------|-------------------------|---------------------------|-------------------|-------------------|
| <i>C. aegerita</i> | 1 | $19.62ab \pm 0.30$ | $2.59a \pm 0.08$ | $3.38bc \pm 0.89$ | 72.79 ± 1.15 | $1.64b \pm 0.55$ | $8.67b \pm 0.49$ |
| | 2 | $20.53ab \pm 0.6$ | $2.77a \pm 0.56$ | $1.38c \pm 0.25$ | 73.86 ± 0.83 | $1.47b \pm 0.35$ | $10.52a \pm 0.15$ |
| | 3 | $21.78a \pm 0.52$ | $2.30ab \pm 0.10$ | $6.81a \pm 0.41$ | 61.45 ± 1.12 | $7.47a \pm 0.17$ | $10.11a \pm 0.23$ |
| <i>P. citrinopileatus</i> | 1 | $17.38b \pm 2.60$ | $1.41b \pm 0.19$ | $4.72b \pm 0.61$ | 67.38 ± 1.64 | $9.12a \pm 1.42$ | $10.33a \pm 0.29$ |
| | 2 | $20.45ab \pm 0.90$ | $1.41b \pm 0.05$ | $3.12bc \pm 0.95$ | 64.90 ± 1.80 | $10.14a \pm 1.19$ | $8.87b \pm 0.05$ |
| | 3 | $22.47a \pm 0.19$ | $1.63b \pm 0.41$ | $2.54c \pm 0.54$ | 65.90 ± 1.63 | $7.65a \pm 0.26$ | $8.22b \pm 0.03$ |
| LSD _{0.05} | | 3.63 | 0.93 | 2.03 | – | 2.76 | 0.80 |
| <i>p</i> | | 0.111 | 0.021 | 0.001 | – | 0.0001 | 0.0001 |

The highest protein content in the experiment ($22.47 \pm 0.19\%$) was found in the fruiting bodies of *P. citrinopileatus*, grown on SC3 substrate, and the lowest for the same species ($17.38 \pm 2.60\%$) when SC1 was used. It should be noted that in both cultivars, fruiting bodies obtained from SC3 had the highest amount of proteins, while those grown on SC1 had the least.

The lipid content in the fruiting bodies of *C. aegerita* was significantly higher ($p = 0.021$) compared to that in *P. citrinopileatus*, but the factor of the influence of the substrate composition on the total amount of fats for individual cultivars was insignificant. The maximum amount of lipids ($2.77 \pm 0.56\%$) was contained in the fruiting bodies of *C. aegerita* obtained from SC2, and the lowest in the fruiting bodies of *P. citrinopileatus* on substrates SC1 and SC2 (1.41%).

According to the results of statistical analysis of the data, significant differences were proved in terms of the content of endopolysaccharides in fruiting bodies of cultivars obtained on different substrates ($p = 0.001$). In particular, a high amount of endopolysaccharides ($6.81 \pm 0.41\%$) was isolated from the fruiting bodies of *C. aegerita*, grown on SC3, and the smallest ($1.38 \pm 0.25\%$) on SC1. The content of endopolysaccharides in the fruiting bodies of *P. citrinopileatus* had less variability from 2.54 ± 0.54 (SC3) to $4.72 \pm 0.61\%$ (SC1). Indicators of the content of other polysaccharides were calculated, but their greatest value was recorded in the fruiting bodies of *C. aegerita* on SC2 substrate ($73.86 \pm 0.83\%$), the smallest

value also for this cultivar, on SC3 substrate ($61.45 \pm 1.12\%$).

As a result of comparing the means by the Mann–Whitney U-Test method, a significant difference was determined between the studied crops in terms of ash content. The highest index was observed for the fruiting bodies of *P. citrinopileatus* obtained from SC2 substrate ($10.14 \pm 1.19\%$), the lowest – for the fruiting bodies of *C. aegerita* from substrates of the same composition ($1.47 \pm 0.35\%$).

Based on the results of two-factor statistical analysis, a significant effect of the content of substrate compositions on the content of dry matter (DM) in the fruiting bodies of cultivars was determined. The highest DM content was observed in *C. aegerita* mushrooms from SC2 substrate ($10.52 \pm 0.15\%$), the lowest – in *P. citrinopileatus* from SC3 ($8.22 \pm 0.03\%$). According to univariate analysis, the fruiting bodies of *P. citrinopileatus* grown on SC1 substrate had the highest DM content ($10.33 \pm 0.29\%$), while the fruiting bodies of *C. aegerita* on the same substrate had the lowest one ($8.67 \pm 0.49\%$).

The chemical composition of the obtained fruiting bodies coincides with the results of previous researchers [23]. For example, under the conditions of *C. aegerita* cultivation on substrates with the addition of fermented chicken manure, the lipid content in the fruiting bodies varied from 1.02 to 2.28%, while the content of crude proteins varied from 27.1 to 37.6% when using the composition «straw / waste / millet» in the ratio 70 : 10 : 20 [12]. According to Musieba [24], the fruiting bodies of the golden oyster mushroom contained $22.10 \pm 2.03\%$ crude pro-

teins on substrates containing straw. So, the investigated substrate compositions make it possible to obtain the fruiting bodies of *P. citrinopileatus* and *C. aegerita* with satisfactory indicators of nutritional value.

Conclusions

The possibility of using agricultural by-products for the effective cultivation of wood-decay fungi *P. citrinopileatus* and *C. aegerita* was investigated. The significant influence of the composition of substrates on technological and chemical parameters of the studied crops was determined. The efficiency of using a substrate composition from barley straw, fuel pellets from sunflower husk, rapeseed, corn flour, and CaCO₃ in a ratio of 40 : 90 : 20 : 25 : 1 by mass fractions was proven. The obtained results made it possible to assess positively nutritional value of fruit bodies by the content of crude proteins in terms of the amount digested in the human body – from 17.38 to 22.47% in dry matter in *P. citrinopileatus* and from 19.62 to 21.78% in *C. aegerita*. The presence of endopolysaccharides in the fruiting bodies of *P. citrinopileatus* (2.54–4.72%) and *C. aegerita* (1.38–6.81%) indicates the possibility of their use as a source of functional substances in therapeutic nutrition.

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Бандура І. І.^{1*}, Кулик А. С.¹, Макогон С. В.¹, Хареба О. В.², Хареба В. В.² Вплив складу субстрату на врожайність і показники харчової цінності плодових тіл їстівних грибів *Pleurotus citrinopileatus* та *Cyclocybe aegerita*. *Plant Varieties Studying and Protection*. 2021. Т. 17, № 2. С. 130–138. <https://doi.org/10.21498/2518-1017.17.2.2021.236519>

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Мета. Установити вплив складу субстратних композицій на технічні-показники та хімічний склад плодових тіл гливи золотої та опенька тополевого. **Методи.** Схема експерименту включала вирощування двох видів дереворуйнівних грибів *Pleurotus citrinopileatus* Singer (штам

2161 IBK) та *Cyclocybe aegerita* (V.Brig.) Vizzini (штам 2230 IBK) на трьох варіантах субстратних композицій. Застосовано лабораторні, лабораторно-виробничі методи оцінки ефективності технології вирощування, хімічного складу отриманої сировини, статистичні методи

аналізу. **Результати.** Структура та склад субстратів впливають на технологічні характеристики культури, фізичні та хімічні властивості плодових тіл. Найкоротший цикл плодоношення у $35,2 \pm 1,7$ доби визначено для культури *C. aegerita* за умов вирощування на субстраті СК1 з формулою «солома / лушпиння / гранули / ріпак / кукурудза / крейда» у співвідношенні 30 : 40 : 70 : 20 : 20 : 1. Найвищу врожайність ($170,5 \pm 15,2$ г на 1 кг субстрату) у досліді визначено для *P. citrinopileatus* на субстраті СК2 з формулою «солома / гранули / ріпак / кукурудза / крейда» у співвідношенні 40 : 90 : 20 : 25 : 1. Плодові тіла *P. citrinopileatus*, отримані із субстрату СК3 з формулою «гранули / ріпак / кукурудза / крейда» у співвідношенні 60 : 110 : 20 : 30 : 1, мали найвищий у досліді вміст білків – $22,47 \pm 0,19\%$, а найменшу кількість білків – $17,38 \pm 2,60\%$ – мали плодові тіла із субстрату СК1. Плодові тіла *C. aegerita* містили більше ліпідів порівняно

з плодовими тілами *P. citrinopileatus*, але чинник впливу складу субстрату на загальну кількість ліпідів для деяких культиварів виявився несуттєвим. Найвищу кількість ендopolісахаридів виділено з плодових тіл *C. aegerita* ($6,81 \pm 0,41\%$), отриманих із субстрату СК3, а найменшу – у варіанті СК1 ($1,38 \pm 0,25\%$). Уміст ендopolісахаридів у плодових тілах *P. citrinopileatus* мав меншу варіативність: від $2,54 \pm 0,54$ (СК3) до $4,72 \pm 0,61\%$ (СК1). **Висновки.** Склад субстратних композицій суттєво впливає на біологічну ефективність культиварів та вміст нутрієнтів у плодових тілах досліджених видів. Отримані результати дають змогу грибівникам спрогнозувати ефективність вирощування та якість отриманих грибів відповідно до використання доступної сировини.

Ключові слова: культивування грибів; глива золота; опеньок тополевий; біологічна ефективність; хімічний склад.

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