Growing of pleurotus ostreatus mushrooms under the artificial light and its influence on d-vitamin content

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Abstract. In the following article are given the results of the designed chamber producing different spectrum, based on light-emitting diodes. It is known, that the light, including the artificial light plays a certain role in the vital activity non-photosynthetic organisms, particularly in mushrooms. In the created by us chambers grown for researches of the content mushrooms, particularly for Vitamin-D study, with the help of modern appliances (SHIMANDZU UV-1800) it is identified and shown, under which spectrum Vitamin-D content increases in the composition of mushrooms pleurotus ostreatus. Altogether Vitamin-D plays an important role in the person’s organism, contributing to absorbing Calcium and Magnesium, helping to strengthen the health of bones and making them hard. There are some predictions that with the help of D-vitamin it is possible to cure cancer diseases in the beginning stage.

1. Introduction
It is known that light is the most important factor which is necessary for the life of plants. Under natural conditions, plants receive the amount of light they require naturally.

Artificial light is used in greenhouses to increase the productivity and quality of agricultural and decorative crops. It is known that light also plays a definite role in the life of non-photosynthetic organisms, particularly in fungi, but its use in the biotechnology of their cultivation is currently limited.

There is a sufficient volume of information on the effect of artificial light of various nature on the morphogenesis, metabolic processes, and productivity of more than 100 species of mushrooms, many of which are producers of biologically active compounds [1, 7, 11]. The analysis of these studies and the experience of their practical use allows to predict the perspective for the use of artificial light, both in industrial mushroom growing, and in the creation of highly productive ecologically pure technologies for the targeted synthesis of the final product. There is also shown the use of artificial lighting, which opens up broad perspectives for targeted regulation of the morphogenesis and metabolism of fungi-producers.

Many types of fungi are actively used by people for food, household, and medical purposes. Currently, about 70 thousand species of fungi have been described, but according to some estimates, up to 1.5 million species of fungi are known [2, 8, 9, 10].

In the work [3, 12], the degree of realization of photoinduction, depending on the composition of the nutrient substratum and the method of cultivation of macromycetes, was proved. It was established that to obtain the maximum stimulating effect after low-intensity laser radiation (LILR) there should be carried out deep cultivation of photoactivated seeding mycelium. Short-term low-intensity laser...
radiation leads to the change in the macromycetes trophism and is expressed in the increase of the rate of biomass accumulation and the efficiency of glucose consumption.

In the work [4, 13], the authors studied the radioprotective properties of aqueous fungal extracts, their effect on the growth and development of the tumor process in the lungs of Af mice, and the possibility of increasing the efficiency of cytostatic therapy of Ehrlich adenocarcinoma.

In the work [5, 14] are highlighted the achievements, problems, and perspectives of the genetic transformation of fungi. The features of fungi that distinguish them from other organisms, which should be considered when preparing material for transformation, are analyzed.

In the work [6], a review and analysis of methods for determining the vitamins of group D are given. In the work [6, 15], the analysis of biological and physicochemical methods, as well as characteristics is carried out. It is shown that physical-chemical methods of analysis in recent years displace biological ones due to their simplicity, expressiveness, sensitivity, and information content. The authors affirm that the future for the analysis of calciiferols undoubtedly belongs to high-performance liquid chromatography (HPLC), as a method that can simultaneously solve all the problems that arise in the analysis of vitamins of group D.

The plants, for the normal development, need not the whole spectrum of solar radiation: only 25% of the rays have the length necessary for the plants (mainly blue, blue-violet, and red areas of the spectrum). Red light activates pigments that affect the growth of the root system, flowering, and ripening of fruits. And blue and violet ones are responsible for the development of leaves and growth of the plant as a whole, and blue light in grown plants, in particular, regulates the width of the mouths of leaves, controls the movement of leaves behind the sun, and inhibits the growth of stems. Artificial light is used in greenhouses to increase the productivity and quality of agricultural and decorative plant cultures. Artificial light is used in greenhouses to increase the productivity and quality of agricultural and decorative plant cultures. It is known that light also plays a definite role in the life of non-photosynthetic organisms, particularly in fungi, but its use in the biotechnology of cultivation is currently limited. There is sufficient information on the effect of the artificial light on fungi of various nature on the morphogenesis, metabolic processes, and productivity of more than 100 species of fungi, most of which are producers of biologically active compounds. There are described mechanisms of photoreactions of different mushrooms, that are an integral part of the targeted photo regulation of their activity in biotechnological processes. An analysis of these studies and the experience of their practical use allows us to predict the perspectives for the use of artificial light both in industrial fungi growing and in the creation of highly productive, ecologically pure products.

2. Materials and Methods

In the given article is shown data about creating the chamber of the different spectrum based on light-emitting diodes and the results of held experiments on the growth and increasing of D-vitamin content in the mushrooms *pleurotus ostreatus*.

Vitamin D (calciferol) is a fat-soluble vitamin known as the “sunlight vitamin”; it appears from the form of cholesterol under the influence of ultraviolet radiation when a person’s skin is illuminated by direct sunlight. Cholesterol is the main building material for vitamin D - it is converted to cholecalciferol, or vitamin D₃, when ultraviolet radiation affects the cells of our skin. It is located mainly in the liver and plays an important role in the human body, contributing to the absorption of calcium and magnesium, helping to maintain healthy bones and making them strong. It is necessary for the growth and strengthening of muscles, as well as the regulation of heartbeat [16, 17].

Lack of sunlight can lead to a deficiency of vitamin D₃, of which the body cannot absorb calcium from food and supplements, and therefore, when its level becomes too low, it takes calcium from the bones to supply the muscles, especially the heart. Other symptoms of vitamin D deficiency include rickets, tooth decay, fatigue, arthritis, burning in the mouth and throat, diarrhea, insomnia, myopia, osteomalacia (softening of the bones – a systemic disease characterized by insufficient mineralization of bone tissue), pain joints, stiffness (hardness, for example, “vascular stiffness” instead of “stiffness of the arteries”; etc.), back pain, baldness and an increased risk of osteoporosis (this is a disease in
which the bones become too thin and brittle, due to its a high degree of risk of fractures). The ability to form vitamin D decreases over the years, so lack of it usually occurs in old-aged people.

Based on the aforesaid, we put the aim of creating a special chamber, giving different spectrum on the ground of light-emitting diodes and technologies of growing and increasing of D-vitamin content in the consistency in the mushrooms of pleurotus ostreatus sort.

Why in mushrooms:
First, mushrooms gain mass very quickly;
Secondly, mushrooms are delicacies;
In addition, for growing mushrooms, a little light is enough.
Primarily we designed from the light-diodes the device of the light source and operated automatically on the experimental processes inside the chamber constructed by us.

Why do we use LEDs? Since it is possible to obtain better and more stable lighting, LEDs consume little energy and emit a small amount of heat. Besides, the composition of the LEDs contains no harmful substances; accordingly, the LEDs do not emit harmful additives.

LEDs emitting the following colors were selected: green, yellow, red, and blue-violet. Four chambers were made and one system of LEDs was inserted into each camera giving the same colors (wavelength) Figure 1. (fig 1.a, fig 1.b., fig 1.c., and fig 1.d. from cameras giving green, yellow, red and purple colors respectively).

Figure 1. From cameras giving green, yellow, red and purple colors respectively.

Herewith, sunlight does not get into the chamber. The system works all the time. At night in low light, and the daytime in high light. The mode was selected using specially installed switches. The system is powered by electricity from voltage networks, which is equal to 220V and with the help of a voltage transformer is reduced to 12 V.

The temperature and humidity inside the chamber were measured with the help of an electronic thermometer and humidometer. The temperature and humidity kept in the average of $t = 25^\circ C$, $f = 80\%$ in all four chambers. Watering was carried out with the help of splasher (rain irrigation).

As we expected, at the same time, a fast growth rate was taken by the mushrooms grown in chambers in which LEDs emitting blue-violet colors hung up. For the normal growth of mushrooms, the necessary substrate is needed. In our case, cotton bolls were used as a substrate for the development of mushrooms. Besides, we created a certain combination of conditions (temperature, humidity). Mixing spores of mushrooms with a cotton box prepared (by the employees of the Department of Agrobiotechnology) substrates in special cellophane and placed these bags in chambers with radiation of spectra of different wavelengths. Humidity and temperature were monitored three times a day and were measured on special electronic devices used to measure humidity and temperature.

Depending on the radiation wavelength (color), the mushrooms had different morphology and differences, and also gained different masses at the same time i.e. stipe length and pileus size depended significantly on the color of the radiation. The following pattern is observed: mushrooms grown under different radiation wavelengths were different in size: the largest mushrooms were grown
in chambers emitting a blue-violet wavelength, smaller ones under yellow and red colors, the smallest sizes were grown under green. Besides, the ugliest mushrooms were grown under green.

To save energy, we used LED lamps. Modern LED light sources make it possible to obtain a given range of lighting. Because LED panels are made in various forms. We made square shapes of LED sources.

The amount of light depends on the distance between the bags of the substrate and the LED lamps. For even illumination of the surface of bags with substrates, we used several dozen LEDs as a light source. To ventilate the chamber, several holes were opened in different places (above and below) of the chamber.

3. Results and Discussion.

Designed by us chamber was very convenient for growing mushrooms and easy for observation of occurring processes during the experiments. It is easily transported from place to place and is semi-automated. It was possible to operate the brightness of light-emitting diodes, it constantly shows the humidity and the temperature of the environment. Herewith, the most essential, it does not use much electricity.

We determined the amount of D-vitamin in the composition of “PLEUROTUS OSTREATUS” mushrooms grown under different wavelengths.

The calculation of the amount of D-vitamin was carried out as follows.

The mushrooms were dried within 4-5 days under the temperature of 25 – 30°C. After that the dried mushrooms passed the phase of extraction with chloroform methyl hydroxide and segregated fats and D-vitamin out of their composition. With the help of spectrometer SHIMANDZU UV-1800 was determined the amount of D-vitamin.

\[
m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V}
\]

The calculation was carried out by the following formulae

\[
m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V}
\]

where \(D_1\) is an optic density of D-vitamin in the samples;

\(D_0\) is an optic density of the standard D-Vitamin;

\(m_1\) is the mass of the vitamin in the samples;

\(m_0\) is the mass of standard vitamin;

\(C\) is a normal concentration;

\(V\) is the volume (ml) of molten (sample) of measuring bulb;

\(ME\) is a million element (m/e).

There was taken a sample of 0.022g measuring in analytic weight the mushrooms grown in the chamber emitting green lighting.

\(\lambda\) is 264nm

\(D_1\) is 0.968

\[
m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V} = \frac{0.968 \cdot 0.059 \cdot 50 \cdot 1}{1.517 \cdot 0.022 \cdot 50} = 171 ME/100 g
\]

2. There was taken a sample of 0.019g measuring in analytic weight the mushrooms grown in the chamber emitting red lighting.

\(\lambda\) is 264nm

\(D_1\) is 1.537

\[
m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V} = \frac{1.537 \cdot 0.059 \cdot 50 \cdot 1}{1.517 \cdot 0.019 \cdot 50} = 314 ME/100 g
\]

3. There was taken a sample of 0.019g measuring in analytic weight the mushrooms grown in the chamber emitting blue-violet lighting.

\(\lambda\) is 264nm
\[ D_1 \text{ is 0.119} \]

\[ m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V} = \frac{0.119 \cdot 0.059 \cdot 50 \cdot 25}{1.517 \cdot 0.019 \cdot 50} = 608 \text{ ME/100 g} \]

4. There was taken a sample of 0.019g measuring in analytic weight the mushrooms grown in the chamber emitting yellow lighting.

\[ \lambda \text{ is 264nm} \]
\[ D_1 \text{ is 0.173} \]

\[ m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V} = \frac{0.110 \cdot 0.059 \cdot 50 \cdot 25}{1.517 \cdot 0.019 \cdot 50} = 562 \text{ ME/100 g} \]

5. There was taken the sample of 0.019g measuring in analytic weight the mushrooms grown in usual conditions (control).

\[ \lambda \text{ is 264nm} \]
\[ D_1 \text{ is 0.883} \]

\[ m(D - \text{vitamin}) = \frac{D_1 \cdot m_0 \cdot V \cdot C}{D_0 \cdot m_1 \cdot V} = \frac{0.883 \cdot 0.059 \cdot 50 \cdot 1}{1.517 \cdot 0.019 \cdot 50} = 181 \frac{\text{ME}}{100g} \]

As it is seen from the results of the quantitative analysis, in the composition of mushrooms grown under blue-violet lightings the amount of D-vitamin is much more than the other samples have.

4. Conclusions

1. We created a special chamber to hold experiments for growing mushrooms of «PLEUROTUS OSTREATUS» sort.
2. As a source of light we used modern light-emitting diodes, assembled on the special platforms of the square shape.
3. Chambers are presented as the semi-automated blocks and easily observe the occurring process during the experiment.
4. Chambers were easily transported from place to place.
5. Light-diodes consume little energy, and emit a not-much amount of warmth and do not emit harmful substances.
6. As we expected the morphology and mushroom content depended on the light spectrum. The largest mushrooms were grown in the chambers emitting the blue-violet spectrum.
7. The amount of D-vitamin is more in the mushrooms grown under blue-violet lighting.

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