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за матеріалами
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**«АКТУАЛЬНІ ПРОБЛЕМИ
ЕНЕРГЕТИКИ ТА ЕКОЛОГІЇ»**

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До збірника включені матеріали сучасних наукових досліджень, що представлені вченими України, Білорусії, Молдови, Росії, а також роботи студентів.

Розглянуто наступні напрямки досліджень: тепломасообмін; теплофізичні властивості робочих тіл енергетичного обладнання; нанотехнології в холодильній техніці; екологічні проблеми енергетики; теплові насоси. Системи опалення та кондиціонування; теплообмінні апарати; енергетичні та екологічні проблеми нафтогазової галузі; енергетичні та екологічні проблеми холодильної техніки; енергетичні та екологічні проблеми харчової промисловості; екологічна безпека; екологічні проблеми сучасності; раціональне використання природних ресурсів.

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Секція 1:

**«АКТУАЛЬНІ ПРОБЛЕМИ
ЕНЕРГЕТИКИ»**

Fig. 2. Kinetics of the layer-wise drying of buckwheat in a microwave field: *a* – change in the moisture content; *b* – temperature change; 1 – upper layer; 2 – middle layer; 3 – bottom layer

Thus, the moisture content of the lower layer increases regardless of the thickness of the sample. The reason for lowering the temperature of the sample at the boundary between the layer and the base of the chamber is the transfer of heat by the conductivity of experimental cell. This irregularity was not observed when using a netted cell that freely passed the steam in all directions. In this case, temperature of the material's layers differed by no more than 4 °C, the humidity – by 0.007 g/kg. Comparing data on the drying kinetics derived at the cell with solid and radiotransparent netted bottom confirmed the importance of rational organization of steam removal. Thus, in the first case the average moisture content of the sample decreased from 0.2 kg/kg to 0.17 kg/kg in 14 minutes, in the second – in 7.5 min. Uneven distribution of temperature and moisture content occurs under conditions when steam removal through the bottom and side surfaces is difficult.

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A MICROWAVE DEVICE FOR THE TREATMENT OF PLANT MATERIALS

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The treatment of plant-based materials is important for the agro-industrial complex. In particular, pre-sowing treatment of seeds is applied to accelerate the appearance of shoots and reduce the plant disease incidence. As a result, the harvest is increased. In traditional technologies, seeds before sowing are warmed, calibrated, soaked in solutions of micronutrients, pelleted, etc. The pre-sowing treatment process is rather lengthy, requires huge material consumption and is not always effective. The pre-sowing seed treatment in the microwave field for biostimulation is simple, energy-efficient and lasts only a few minutes compared to traditional methods. Microwave biostimulation of seeds is associated with an increase in the transport properties of plant tissue due to the development of high-pressure gradients in closed micro volumes of microfibrils of cell walls and pores [1]. The influence on cell walls leads to an increase in the translocation of nutrients and improves seed sowing qualities. Effective use of the voluminous nature of microwave heating can be obtained by preparing a plant substrate for tree-destroying fungi. Plant material after the MW treatment is not only

disinfected but also improves its nutritional properties due to the break of cellulose fibers [2]. Unlike traditional pasteurization and sterilization technologies, the energy consumption and duration of the process of the MW substrate preparation are significantly reduced.

We have tested the microwave device (Fig. 1) of continuous operation for the thermal treatment of plant materials, which was developed and designed to implement microwave technologies in the industry.



Fig. 1. Microwave device for thermal treatment of bulk materials

The purpose of the tests was to assess the effectiveness of the microwave device by the indicators of quality of the obtained material and energy consumption determined by the efficiency of the conversion of microwave energy into the internal energy of the material.

The effects of microwave treatment of a straw substrate for tree-destroying fungi were studied. The treatment quality was determined by the yield of Oyster (*Pleurotus*) mushrooms, grown on the obtained substrate. Microwave treatment was carried out in various modes, which differed in the value of specific power. When analyzing the effectiveness of microwave treatment, the results were compared with the data obtained during the application of the traditional technology of straw sterilization. It was shown that the harvest of Oyster mushrooms increased by 11 %. It was found that under the optimal mode, specific power was $q_v=8.68 \cdot 10^5 \text{ W/m}^3$, final temperature was $t=96 \text{ }^\circ\text{C}$, duration of treatment was 180 s. Based on the thermal calculations, the values of the microwave chamber efficiency η_c were calculated; under the optimal mode, $\eta_c=62 \text{ } \%$. The influence of the microwave treatment on the sowing characteristics of seed wheat grain was studied. The effectiveness of the microwave treatment was determined by the values of laboratory germination and seed germination energy. Under the optimal mode, the output power of magnetrons was $\Sigma P_{\text{out}}=0.6 \text{ kW}$, the grain consumption was $G=2.1 \cdot 10^{-2} \text{ kg/s}$. The study of the microwave device operation showed that for this design, in order to ensure stable and uniform movement of the material along the product pipeline, it is necessary to maintain the movement speed that is not higher than 0.5 m/min. It is recommended to apply the tested microwave device of continuous operation on specialized farms.

The results of microwave testing show that microwave treatment is more effective than traditional sterilization (Table 1). Energy consumption under the optimal mode of microwave treatment is five times lower, in addition, the treatment duration for small volumes is significantly lower, as sterilization involves keeping within three hours.

The data of Table 1 show that the increase in temperature up to 96–96.5 °C leads to an increase in the weight of mushrooms, which is supposedly associated with the scattering of pulp and an increase in nutritional qualities for oyster mushroom. This assumption is supported by research [2]. The CT mode is the treatment of straw in the chamber-sterilizer using the traditional technology according to the modes set for this treatment (the temperature at sterilization reaches 120 °C, the pressure is 1.5 atmospheres). The duration of sterilization takes about 3 hours, which is much longer than the time of microwave treatment. Control K is the mode, in which heat treatment was not carried

out, straw was soaked in hot water and after pressing was inoculated with mycelium. Mode 4 can be considered optimal because it gives almost the maximum possible yield of mushrooms, and specific energy consumption was minimal, in addition, the maximum efficiency of the chamber was reached.

Table 1 – The number of mushrooms grown on the substrate after the treatment in the MW field
Initial humidity $W=73\%$

No.	$q_v, \text{W/m}^3$	Final temperature, °C	Result (yield per unit, kg)	$Q_m, \text{MJ/kg}$	$\eta_c, \%$
1	$7.24 \cdot 10^5$	72	2.35	0.38	48
2	$7.64 \cdot 10^5$	77	2.86	0.31	52
3	$8.12 \cdot 10^5$	92	3.64	0.25	60
4	$8.36 \cdot 10^5$	96	3.88	0.23	62
5	$8.68 \cdot 10^5$	96.5	3.90	0.23	59
6	$12.2 \cdot 10^5$	123	3.61	0.25	57
CT	–	120	3.50	1.15	–
K	–	20	0.350	–	–

Testing the developed device under different treatment modes solves the problem of switching to the practical application of microwave technologies. Developed microwave device of continuous operation can be used in the established optimal modes for thermal treatment of bulk materials in the technologies of biostimulation and preparation of substrate for tree-destroying fungi. In the future, it is advisable to test the microwave device for the sterilization of combined feed. In this case, the developed device can get wider use.

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STUDYING THE HEAT EXCHANGE OF A DENSE LAYER OF GRANULAR MATERIAL WITH THE AIRFLOW

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An experimental plant simulating the actual heat exchange channel of the regenerator was designed and manufactured for the research. The plant provides heating of a dense layer of material and makes it possible to measure air temperature at the inlet and outlet of the channel, the temperature of the material at selected control points, and the flow rate. The channel was filled with granular material when it was mounted in an upright position, for which the possibility of channel disconnecting from the duct is envisaged. Mesh plugs with rubber seals are provided to fix the layer in the channel. The circuit of the experimental plant is shown in Fig. 1.

ТЕПЛОФИЗИЧЕСКОЕ МОДЕЛИРОВАНИЕ ПЛАСТИНЫ МИКРОКАНАЛЬНОГО ТЕПЛООБМЕННИКА С ОТВЕРСТИЯМИ ЖАЛЮЗИЙНОГО ТИПА	
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