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PhD thesis

Contributions on monitoring and adjusting the parameters of the culture medium mushrooms of the genus Pleurotus

Abstract

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News and legal necessity.

Developing this work is closely related to the research conducted under the theme of the Research of Excellence "Innovative Biotechnologies to produce functional food of the genus Pleurotus mushrooms and prepare industrial exploitation.

Lately culture began to mushroom heads look very different. Until today, worldwide, known technology culture 14 edible species. In Europe to obtain over 58% of world production, which is estimated at over 1,500,000 t (2000 t in Romania). Nutritional value and cultivation technology more economical, required expansion in culture of mushroom species of the genus Pleurotus, occupying second place in culture and in the genus Agaricus consumption. After the big nutritional and therapeutic values are placed in the first place.

Because of their importance and therapeutic food, determined by chemical composition, but not least better awareness by consumers, have favored the expansion of cultivation areas and increased needs for the market.

Pleurotus mushrooms are a dietary food for human alimentation. Have a high protein, almost as a substitute for meat. Also contain sugars, organic acids, minerals and real sources of vitamins, especially the B complex and vitamin D. biologically active substances contained in these mushrooms growing, diminishing the harmful effects of radioactive elements from the human body and the big protein prevents and cure hepatitis, gastric ulcer, decreases the percentage of cholesterol and act anti-cancer. In addition, these mushrooms have anti-business, anti-inflammatory and antibiotic.

On the national genus Pleurotus mushrooms are consumed more fresh (in which case they keep 2-3 days) or in chilled and packaged (with storage period of 7-10 days). Are part of highly perishable vegetables, and limited capacity due to conservation and low sales opportunities offered by the development of limited marketing your product, the production of mushrooms become truly profitable provided it is accompanied by processing. In general, both in country and abroad, genus Pleurotus mushrooms are less processed, it will be consumed more fresh. Species in our intensive culture of the country are: Pleurotus Ostreatus, Pleurotus Florida Cornucopiae Pleurotus, Pleurotus Sajor-Caju and various hybrids of domestic production or from the European Union.

The main purpose of the thesis consists of an automated system for monitoring and adjusting the parameters of the culture medium mushrooms of the genus Pleurotus enabling research on the influence of specific parameters of quality monitoring in order to increase food quality by rigorous control of the environment and culture specific for labor productivity growth in the horticultural sector.

To achieve the proposed goals were established the following **objectives**:

- mathematical-modeling and numerical simulation of the microclimate of the Incubation and fructification;
- control and routing technology automatically sequences specific crops of mushrooms;
- dedicated to designing software for processing data obtained by monitoring the microclimate;
- a computerized system for monitoring and adjusting microclimate parameters (temperature, humidity, lighting, ventilation).

Degree of achieving goals.

It considers that the objectives were met in full.

Theoretical and methodological support scientific.

To achieve the proposed objectives were consulted books, patents, PhD theses, journals and proceedings of scientific research units - development of the country and abroad with concerns in the field.

Given the theme of interdisciplinary, research methodology aimed at both the monitoring and adjusting the parameters of the environment and culture influence these parameters on the monitoring process - mushrooms of the genus Pleurotus.

Novelty scientific and technical results.

Scientific novelty is related to:

- Mathematical model for the heating of space Incubation;
- The mathematical model for heat transfer processes in space Incubation;
- The constant ventilation used to describe the efficiency of passive climatization Incubation space;
- Numerical simulation of the heat transfer in space to optimize Incubation Incubation-fructification cycle and reduce total electricity consumption;
- Mathematical model for the elimination of carbon dioxide released from mushrooms of the genus Pleurotus space fructification;
- Numerical simulation of the recirculation of air space fructification taking into account the phenomenon of convection and diffusion;
- Estimate the temperature distribution in space Incubation in reducing the number of physical sensors in this area, given the variable nature of the structure of this space;

- Estimate the concentration distribution of carbon dioxide and humidity distribution throughout the fructification to reduce the number of physical sensors in this area, given the variable nature of the structure of this space;

Technical novelty is related to the monitoring and adjusting the parameters of the environment and culture made the demand for patent trap *Air filter for the Incubation of the fungus*.

Applicative value of the sentence resulting from the fact that the monitoring of environmental parameters culture MONIMAS works at Station brambles Banu Mărăcine at the University of Craiova ensuring the conduct of specific research in the field of Horticulture. Some results have been applied, in part, and another national research project (research on a rail vehicle for intelligent transportation safe, comfortable and efficient passenger).

Also, the practice of the sentence can be associated and that the results represent a continuation of applied research conducted by the author in the last ten years in the area of automation and monitoring applied to industrial customers and have been the subject of 24 research contracts of which:

- At 5 am responsible: 2 national contracts obtained through competitive contracts and 3 operators;
- 12 national contracts obtained through competition or selection;
- 7 contracts with operators.

Dissemination of results.

The results were the subject of 38 scientific works, displayed and discussed at various conferences and seminars, national and international scientific and published in specialized journals or in conference volumes, of which:

- 8 are directly related to monitoring and adjusting the parameters of the culture environment of the genus Pleurotus mushrooms, these are the first author;
- 10 topics related to developing monitoring and adjusting electrical parameters of other technical systems. As they were used in part results in the thesis or the results presented in this work were developed in the thesis. In these works I was coauthor.
- A paper refers to the electric heating system for space application Incubation;

- 17 works develop themes of automation and other technical processes have been used in part results in the thesis or the results were applied in the thesis. In these works have been co-author;
- One subject to the patent application of invention to the biological filter for space Incubation;
- One subject to the patent application for invention for the movement of electricity in isolated systems with photovoltaic panels that will be used for further research on reducing energy consumption on the premises of sub culture.

Sentence structure.

This paper contains a number of 177 pages, comprising seven chapters in which they are displayed: research relationships with 62, 136 figures, 15 tables, final conclusions, personal contributions, a total of 109 bibliographical list of bibliographic entries of the 9 positions is author and coauthor in 9 and 12 annexes.

First (*Chapter 1*), to monitor and adjust environmental parameters of a fungus culture, was an analysis of existing national and international culture of fungi and in particular those of the genus Pleurotus, the importance of the nutrient and especially from the therapeutic. From this analysis done, the resulting sentence, because of demand in the domestic market and foreign mushroom Pleurotus value therapeutic food and high enrollment in the thesis concerns of European innovative technologies on food processing and food including fine food and quality not alteration environment because the technology of cultivation of these mushrooms.

In *the second chapter*, an analysis was made of the cultivation of mushrooms to election monitoring solution and have presented the general characteristics (morphological structure to Pleurotus mushrooms, phenophase growth, the temperature, humidity, ventilation and lighting) and technology general cultivation mushrooms focusing on areas of culture and the culture.

In *the third chapter*, from necessity more precise knowledge of the processes subject to regulation and monitoring, a study on environmental parameters influence on the phases of Incubation and fructification of importance in ensuring the microclimate, and implicitly on the quality of mushrooms produced. Thus, making modeling of the phenomenon of air spaces in the liberation of heat and the phenomenon of heat transfer between the interior space for incubation and outside, both by conduction and by convection and conduction. Is presented still a model of air recirculation, where the release of carbon dioxide and then identifies the phenomenon of recirculation air spaces of

production, if the air flow is by convection, either through convection and diffusion. Identify allowed to be a typical curve to a response ventilation will process a change of momentum or a rung of carbon dioxide concentration. Also in this chapter, shall conduct a review of the process of moistening of the fructification up to the possibilities of adjustment of this parameter for two extreme situations: summer, winter.

Chapter four is dedicated to achieving the system of monitoring and adjusting the parameters of the culture medium Incubation space. Thus, the first type is determined sensors needed temperature measurement is achieve then an estimate of the distribution in the area of Incubation, to determine the number of temperature transducers. Further, it presents the necessity and possibility of air treatment introduced Incubation space in order to ensure a sterile environment and performance of the computerized system designed for this space, including the following interconnection subsystems functional distinct hierarchically superior a computer (PC), an equipment numerical data acquisition and sensors for measuring temperature microclimate. The number allows scanning sensors and used transducers buying information and passing it to the upper hierarchical structure and performance of sequences of the specific operation.

Chapter five is dedicated to the monitoring and adjusting the parameters of the culture environment of the fructification. To achieve this system, after determining the parameters for this decision process (the concentration of carbon dioxide, moisture and temperature), the type is set transducers for measuring these parameters, and then make an estimate of the distribution of carbon dioxide and humidity inside the space fructification of the determination number.

Equipment for digital monitoring and regulation of environmental parameters in space crop fructification is made of several blocks components of the microcontroller, block adjustment, serial communication block, block and power block command. The software developed allows the acquisition of information from sensors and the number of entries to process, store them in a database or in the form of text files, processing information so as to raise the issues highlighted that are of interest, comparing results with reference values (monitoring) and to generate the order of process execution, based on numerical algorithm micro-systems control (automation). Dedicated software is structured in two parts: the first allows the acquisition, processing and saving the information obtained, and the second performed the analysis and generation of command elements for execution. The first part of the hierarchical structure allows the connection with the higher numbers, systematically verify the proper functioning of the whole assembly, testing continuously received information to alert the operator to a technical problem or other.

Acquired information are stored in central computer memory, making it available for the second part of the program. Using Visual Basic program, the impressive picture of resources, efficiency, organization and breakdown of functional problems, resulted in obtaining an easy to use, complete and similar models on the market.

Experimental results on the system proposed and achieved are presented in *chapter six*. Experimental system for monitoring and adjusting the parameters of the culture environment has been growing in the space arranged in the resort of teaching at the University of Craiova. These results confirm the accuracy of models and analyzed the influence of environmental parameters on the quality and quantity of cultivated mushrooms. To check the response and behavior of the system for different disturbances that may occur in the process and information obtained from sensors with the help of standard devices.

Contributions.

1. Theoretical Contributions

I appreciate that, by developing doctoral thesis, I made the following theoretical contributions:

- Develop the mathematical model for the heating of space Incubation;
- Develop the mathematical model for heat transfer processes in the area of Incubation;
- Determine constant ventilation used to describe the efficiency of passive climatisation Incubation space;
- Numerical simulation of the heat transfer in space to optimize Incubation Incubation-fructification cycle and reduce total electricity consumption;
- Develop the mathematical model for the elimination of carbon dioxide released from mushrooms of the genus Pleurotus space fructification;
- Numerical simulation of the recirculation of air space fructification taking into account the phenomenon of convection and diffusion;
- Estimation of temperature distribution in space Incubation in reducing the number of physical sensors in this area, given the variable nature of the structure of this space;
- Estimation of the concentration distribution of carbon dioxide in the space of fructification to reduce the number of physical sensors in this area, given the variable nature of the structure of this space;
- Estimated distribution of moisture in the fructification to reduce the number of physical sensors in this area, given the variable nature of the structure of this space.

2. Contributions software

• Develop software for system monitoring and adjusting the parameters of the culture medium mushrooms of the genus Pleurotus in a language specific industrial applications (Visual Basic 6), which allows acquisition of information from sensors and the number of process inputs, storing them in a database or in the form of text files, processing information so as to raise the issues highlighted that are of interest, comparing the results with reference values and generating the command to the execution of the process, the specifically the algorithm proposed.

• We designed a specialized program for monitoring and adjusting the parameters of space Incubation (Annex 11)

• We designed a specialized language under routine C sensor for carbon dioxide for the calculation of CRC (cyclic Redundant Check) that calculates a sum of shared control arithmetic. Bit sequence is divided by the number chosen. The division is done in modulo 2, or using the XOR operator. The remaining division is the signature to be added to the end, after the useful bits. Divisor is obtained with the algorithm used to Hamming codes. On arrival, the remainder is recalculated and if the division does not coincide with the received sequence is then wrong. Performance of this method are impressive. CRC is detected: all the errors in the maximum gust of 16 bits, all the odd bits of error, 99,998% of all errors of any length (Annex 5).

• have developed programs dedicated to estimate the temperature distribution in space Incubation for estimating the distribution of moisture and carbon dioxide in the space of fructification.

3. Contributions hardware

• Develop a flexible system for monitoring and adjusting the parameters of the culture medium of fungi of the genus Pleurotus, including the interconnection between a computer hierarchical superior, two specialized programs for automated data acquisition and sensors for measuring parameters of microclimate;

• Establish specialized automatic programmable I MICROMAS providing acquisition and display information on the temperature in space and space Incubation of fresh air intake and status of implementation elements that ensure that the parameters of the Incubation space: doors, fans, filters, sources of heating (cap. 6.1.3). It also provides automatic MICROMAS I command the elements of implementation specific fans for fresh air intake, sources of heat, a biological filter;

• The automatic programmable MICROMAS F specialized programs that ensure the acquisition of signals provided by local modules located in the area of fructification, the status of implementation elements that ensure that environmental parameters of the fructification of the fungi of the genus Pleurotus: doors, fans, lamps lighting (head. 6.2.2). It also provides automatic MICROMAS F values showing concentration of carbon dioxide and moisture and the elements of command execution specific fans for fresh air intake and exhaust carbon dioxide from the fructification of a plant and moistening of the lighting;

• The local modules (cap. 6.2.1) located in the fructification of modules that provide the link between hardware-specific sensors and programmable automatic MICROAS F.

• The transducers of carbon dioxide and humidity sensors based on providing information in numerical form.

• The biological filter with ultraviolet radiation (cap. 6.1.2) which can be mounted on the vent pipes can be coupled to automatic programmable MICROMAS I provide heating fresh air brought into the area of Incubation.

4. Contributions Experimental and Applied

Experimental contributions refers both to the monitoring and adjusting the parameters of the environment and culture to influence these parameters on the monitoring process - mushrooms of the genus Pleurotus.

a) contributions on the monitoring and adjustment.

• experimental results on the system of monitoring and adjusting the parameters of the culture medium of fungi of the genus Pleurotus, demonstrates the correctness of proposed solutions to resolve problems identified.

• practical contributions have been fully implemented in the Project CEEX nr.21/2005 "Innovative Biotechnologies to produce functional food of the genus Pleurotus mushrooms and prepare industrial exploitation" and partly in the Project CEEX 126 / 2006 "Research on an intelligent rail vehicle transport for sure, comfortable and efficient travel.

• create a flexible system of data acquisition necessary for production process management and monitoring parameters that it influences the system that can be customized for other geometry of space culture.

• The filter with ultraviolet radiation for disinfection fresh air introduced into the space Incubation, filter that eliminates the disadvantages known solutions, it can be mounted on pipes and artificial ventilation may be coupled to specialized programmable automatic

power and efficiency of the heating element composition to increase with increasing air flow and its regulation is based on the temperature required Incubation space.

b) contributions on the influence of environmental parameters on the horticultural crop.

• To set the reference temperature of space Incubation at a higher value than that recommended by the literature and noted a decrease in the duration of the Incubation and fructification, but with negative effects in terms of nutritive value and commercial mushrooms (head. 6.1.4, 6.2.3).

• To set the reference of carbon dioxide in the fructification of a value greater than that recommended by the literature and were observed the following effects: buttons appear in a small number at the same level and are poorly developed, the stagnation of growth button, foot fungus is thicker compared with the hat; carpoforii (hats) are poorly developed and have a reduced growth rate; brunches not have commercial value and must be removed to allow the formation of other items fructification.

• adjust the reference moisture values outside the scope recommended by the literature and observed decreased nutritive and commercial value of the fungus.

Proposals and research directions

• Given that there is a filter manufacturing process of biological dedicated Incubation of the fungus is proposed transfer technology to a producer.

• It is proposed to propose further research direction on the use of heat pumps to provide the necessary heat.

• We propose further research direction on the use of photovoltaic panels to provide the necessary electricity.

• It is believed that research could be continued to influence the direction of pressure on the analysis of heating process of the Incubation hall, where the use of fans involved with vieta variable electric motors supplied by static converters.