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MYCOTECHNOLOGY FOR VALORISATION OF FRUIT TREE WASTES AS ECO-FRIENDLY AND USEFUL PRODUCTS

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Abstract

The main aim of this work was to set up the optimal mycotechnology for valorisation of fruit tree wastes by using them as growing sources for Basidiomycetes mushrooms, in order to get eco-friendly and useful products. In vitro experiments were carried out through controlled cultivation of two mushroom species, Ganoderma applanatum and Ganoderma lucidum, on substrates made of fruit tree wastes. There were set up three variants of substrates consisting of lignocellulosic wastes belonging to apple, plum and cherry trees, mixed with cereal grain wastes, such as wheat and barley bran, which were placed in ceramic trays and metal pots. After thermal sterilization and inoculation with the pure mushroom cultures, the substrates were placed inside growth chambers at the temperature of 23 °, the air flow volume exchanges 3-5 m3/h and the relative humidity content 90-95%, RU. The mushroom growth inside the substrates made of lignocellulosic wastes has followed the controlled biotechnological aiming to minimize the duration of cultivation and maximize the final production eco-friendly materials and biodegradable products.

Key words*: Ganoderma applanatum, G. lucidum, lignocellulose wastes.*

INTRODUCTION

The excessive producing of redundant lignocellulosic materials, followed by their long-term accumulation as outcome wastes from forestry and agriculture activities has become a great challenge, which has to be solved only through biological means to get beneficial products for human society (Soetaert & Vandamme, 2006; Sanchez, 2004).

As a matter of fact, one of the most important targets in the field of lignocellulose waste conversion into beneficial products is mainly focused on the screening of performant biotechnological methods which use mycological tools to get new eco-friendly materials, highly appreciated as building ang packaging materials (Bayer et al., 2019; Kumar et al., 2020; Lange, 2017).

Thus, during the last decade, a few technological procedures to be used for producing of those new products from organic wastes through their bioconversion made by mushroom species were established (Lange, 2014; Grimm & Wösten, 2018).

The main purpose of this work was focused on the setting up of optimal mycotechnology for valorisation of fruit tree wastes by using them as growing sources for two mushrooms species, namely, *Ganoderma applanatum* and *G. lucidum*, in order to get eco-friendly and useful products (Zhang, 2008).

Implementing the functional model of such green valorisation of lignocellulosic wastes by using the specific mycotechnology, the envisaged results will be achieved by a standardized production of eco-friendly materials through controlled growing of selected mushrooms belonging to *Ganoderma* genus (Petre et al., 2016).

MATERIALS AND METHODS

Mushroom species used in experiments

Following the main purpose of this research work, two mushroom species belonging to Basidiomycetes group were selected as biological tools, *Ganoderma applanatum* (Pers.) Pat., and *G. lucidum* (Leyss. Ex Fr.) Karst. (Wainwright, 1992; Smith, 1998; Stamets, 2000).

The first one is a saprobic or, sometimes, parasitic mushroom, inedible, living solitary or scattered, on decay deciduous wood or on living woody trees all year-round, and the second one is considered as a healing mushroom being used in traditionally Chinese medicine over many thousands of years (Ragauskas et al., 2014; Rani et al., 2008; Verstraete & Top, 1992; Van der Twell et al., 1994).

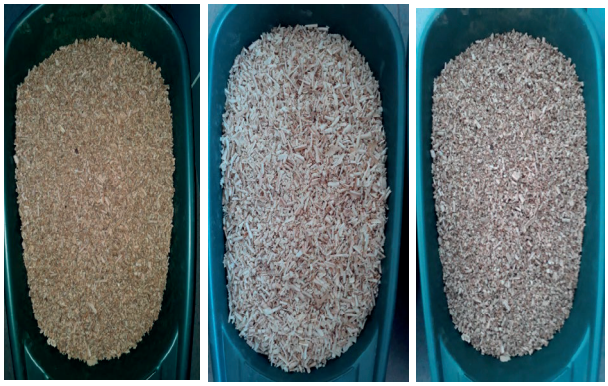
The cultivation of selected mushrooms

Preparation of nutritive substrates for controlled cultivation of mushroom species was achieved by using woody dried materials chopped and split in relatively equal sized fragments of 3-5 cm. To these woody materials were added natural ingredients to enhance the growth and development of the mycelium belonging to those mushroom species already mentioned (Robinson et al., 2001).
There were set up three variants of mushroom cultivation substrates made of lignocellulosic wastes belonging to apple, plum and apricot trees, mixed with cereal grain wastes from milling industry, such as wheat bran (5% w/w) and barley bran (5% w/w). Beside these three substrate variants, it was used the pure cellulose (Merck) as control. Natural ingredients were added to each variant of substrate in the same percentage, such as, barley and wheat bran, in order to stimulate the enzymatic activity of mushroom species, as well as processes of growth and development of mycelia biomass, according to Table 1.

Table 1. The substrate variants used for controlled cultivation of mushrooms

Substrate variants	The composition of substrates (dry weight)
S1	Apple branches 75%, apple leaves 15%, barley bran 5%, wheat bran 5%
S2	Plum branches 75%, plum leaves 15%, barley bran 5%, wheat bran 5%
S3	Apricot branches 75%, apricot leaves 15%, barley bran 5%, wheat bran 5%
Control	Pure cellulose (Merck)

This experimental model was carried out by ensuring optimal growth conditions for mycelium belonging to woody mushrooms belonging to the species *Ganoderma applanatum* and *G. lucidum*, which were grown on cultivation substrates consisting mainly of lignocellulosic wastes resulting from annual cuttings of trunks and branches of fruit trees, such as apple, plum and cherry, as it is shown in Figure 1.



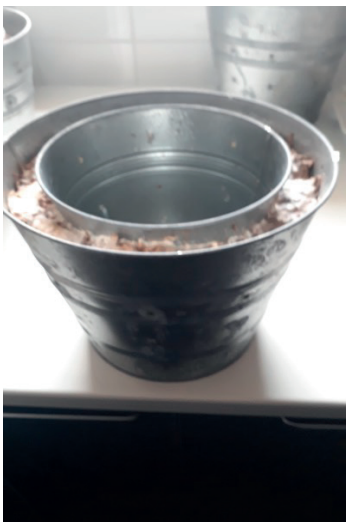
a) b) c)
Figure 1. Fruit tree wastes, chopped and shredded: a) apple; b) plum; c) cherry

These fruit tree wastes were fragmented to sizes of a maximum of 2-3 cm, which were mixed with barley bran and wheat bran and then inserted inside ceramic trays of parallelepiped shapes, having dimensions similar to the bricks used in constructions, with the surface area of 200 cm and a height of 10 cm (Figure 2), as well as inside metallic structures, shaped as pots (Figure 3), over which was added water as 20% per fresh weight of the whole composition and kept hydrated for 10 hours (Appels et al., 2019; Attias et al., 2020).
Then, all these ceramic trays as well as metal pots, filled with the substrate variants made of fruit tree wastes, were sterilized with steam under pressure for one hour at 128°C, and after cooling, they were inoculated with pure cultures of the aforementioned mushroom species, after which they were kept into a growing chamber, keeping the constant temperature of 23°C, the air humidity of 90-95% RE and the filtered air flow of 3 volume exchanges for 30-45 days, depending on the species used as inoculum source (Saddler et al., 1993; Jones et al., 2018). After the incubation period, each one of the mushroom species used in experiments of controlled cultivation has developed a consistent mycelium net inside the inner structure of the substrate variants, the final products being shown in Figures 2 and 3.

a) b)

Figure 2. Ceramic trays containing the mixture of fruit tree wastes impregnated with mycelium of mushroom species *Ganoderma applanatum* (a) and *G. lucidum* (b)

a)



b)

Figure 3. Metal matrix in the shape of conical support consisting of fruit tree wastes inoculated with mycelia of *Ganoderma applanatum* (a) and *G. lucidum* (b)

RESULTS AND DISCUSSIONS

The final products of such laboratory-scale mycotechnology which were obtained after the complete growth cycles of both mushroom species are divided in two categories.

The first one is represented by the eco-friendly building materials with hard, compact and homogeneous structure, in the form of blocks containing lignocellulosic fragments, which have been completely covered by a network of mycelial hyphae during the incubation period, possessing a fireproof, hydro composite and heat-resistant structure, with high hardness and complete resistance to mechanical actions (Islam et al., 2018).

Finally, the blocks of fruit tree wastes, which were impregnated with the mycelium of the mentioned mushroom species during the incubation were dried, either slowly, at room temperature for 5 days, in direct air flow, or much faster, in an oven at the constant temperature of 50°C, for 15 hours, in this way it can be stored for a long time without degrading (Figure 4).

a)

b)

Figure 4. Eco-friendly materials in shepe of blocks, consisting of fruit tree wastes impregnated with mycelium of *Ganoderma applanatum* (a) & *G. lucidum* (b)

The second category of final products were obtained as fully biodegradable materials, which can be used as functional containers in the shape of pots that can be planted right into the fields or gardens, eliminating the root shock. These pots are made of 100% fruit tree wastes and mushroom mycelia developed inside the inner composition of cultivation substrates (Figure 5).

a)

b)

Figure 5. Eco-friendly materials in the shape of conical supports consisting of fruit tree wastes impregnated with mycelium belonging to the species of *Ganoderma applanatum* (a) and *G. lucidum* (b)

According to the main results of this research work, the mycotechnology for valorising the fruit tree wastes by using them as growing sources for mushroom species *G. applanatum and G. lucidum* was established at laboratory scale, as it can be seen in Figure 6.

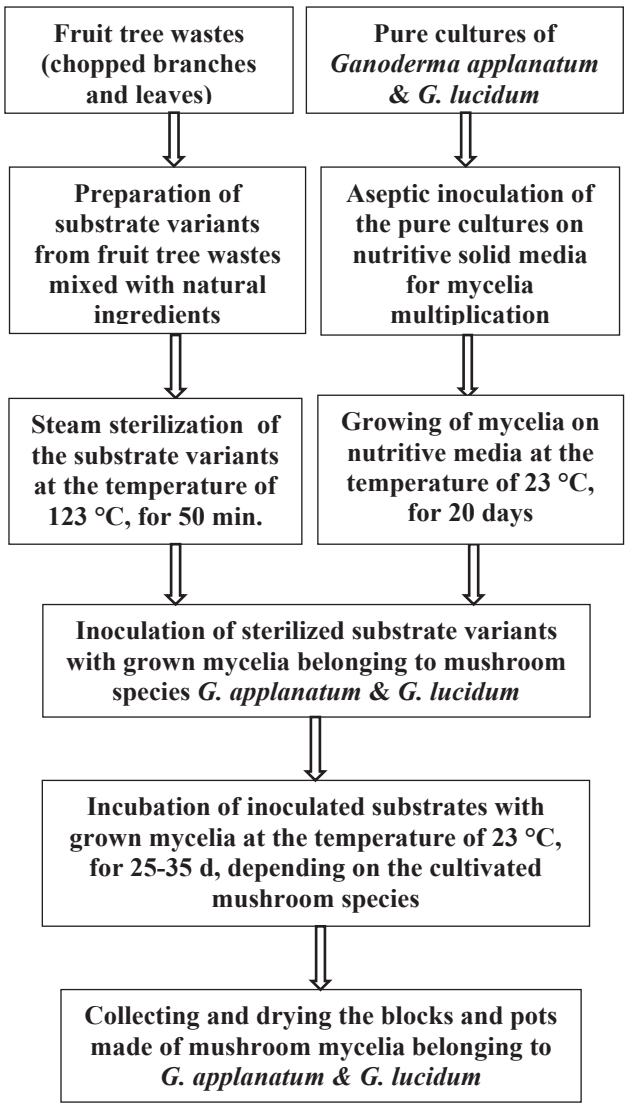


Figure 6. The scheme of mycotechnology applying for valorisation of fruit tree wastes as eco-friendly products by controlled cultivation of mushroom species *Ganoderma applanatum* and *G. lucidum*

The final products of this laboratory-scale biotechology are framed in two major categories. The first one is represented by the eco-friendly building materials with hard and compact structure, in the shape of building blocks containing lignocellulosic fragments of fruit tree wastes, which have been completely covered by a network of mycelial hyphae.

The second category of final products is referring to fully biodegradable materials that can be used as: completely biodegradable pots, supports or protective structures which are made of the compost resulted from mushroom mycelia growing inside the structure of lignocellulosic wastes.
Thus, these fully biodegradable materials can be used as functional containers in the shape of pots that can be planted right into the fields or gardens, eliminating the root shock. These pots are made of 100% recycled and composted lignocellulosic wastes by mushroom growing.

CONCLUSIONS

Taking into consideration the main results of this work as significant elements of innovation and relevance for the state-of-the art in the field of lignocellulosic waste valorisation as useful products, the following conclusions should be mentioned:
a. the valorising of all types of lignocellulosic wastes through controlled mushroom growth getting the total recycling of such renewable resources (tree chopped branches, wood chips, sawdust from forest industry, as well as fruit tree wastes) as raw materials for mushroom biomass development is the best way to produce eco-friendly materials;
b. the implementation of a performant mycotechnology for economic efficient recovery of lignocellulosic wastes and their bioconversion into eco-friendly building blocks as well as useful biodegradable materials
c. the novelty and practical importance of this work are mainly due to the innovative mycotechnology designed to recycle a lot of useless lignocellulosic materials in order to obtain simultaneously two valuable products, with low expenses of energy, raw materials and workforce, comparing with the same procedures in this field.
The whole bioprocess of mycelium growth inside the substrates made of lignocellulosic wastes followed the controlled biotechnological procedure to minimize the duration of mushroom cultivation and maximize the final production of eco-friendly materials and biodegradable products.
The mycotechnology for valorisation of lignocellulosic wastes outcome from fruit tree culture through controlled mushroom mycelia growing could be considered as efficient demonstration model of producing new eco-friendly and useful economic products.

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