EVALUATION OF DIFFERENT WOOD BY-PRODUCTS FOR SUSTAINABLE BUILDING BIOMATERIAL PRODUCTION USING FUNGAL MYCELIUM

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ABSTRACT

As human population increases, the demand for new innovative, sustainable, and low impact construction materials also grows. Mycelium-based composites have shown to be an excellent alternative for traditional products in the sector. Waste streams from other productive processes can be used as feedstock, enabling the upcycling of materials in the pursuit of a circular economy. In this study, three different experiments were carried out to develop a variety of mycelium bio-composites from wood by-products. *G. lucidum, T. versicolor* and *P. ostreatus* grown at 25 °C were chosen due to their fast-developing rate and mycelium density in comparison to *P. eryngii* and *F. pinicola*. Using a 1:1 mix of wheat and millet was found to significantly improve mycelium growth for spawn production rather than using the grains separately. Lastly, the shortest bio-composite production time and most visibly homogeneous material was obtained when growing *G. lucidum* on beechwood. However, other preliminary tests demonstrated the potential of mixed substrates for reducing the material's production time.

Keywords: Mycelium based composites, fungal mycelium, lignocellulosic materials, wood by-products, material bio-fabrication.

INTRODUCTION

In recent years the demand for sustainable building materials has increased due to the continuos growth of globlal population and the scarcity of raw materials (Elsacker et al. 2020).

Mycelium-based composites have become an interesting solution in this matter. As the mycelium works as a natural biological binder on solid organic matter (Jones et al. 2017, Tacer-Caba et al, 2020), it opens the possibility for upcycling lignocellulosic materials and by-products of other industrial and agricultural processes that are currently treated as wastes (Jones et al. 2020).

These new materials are versatile and can be used in different applications from low-density and planar objects to semi-structural materials for panelling and flooring (Yang et al. 2021, Jones et al. 2020). Additionally, they have proven to meet functional requirements including thermal and acoustic insulation and fire resistance (Attias et al. 2020, Jones et al. 2020, Elsacker et al. 2021).

The objective of this research was to evaluate different fungal strains, wood-byproducts and conditions in order to elucidate a feasible and fast process for mycelium composite production for semi-structural applications using wood waste materials with no commercial value as feedstock.

MATERIALS AND METHODS

Several growth tests were carried out using different materials and the fabrication method specified below.

1 | Fungal strain selection →

Potato dextrose agar (PDA) petri dishes:

Trametes versicolor
Ganoderma lucidum
Pleurotus ostreatus
Pleurotus eryngii
Fomitopsis pinicola

Grown at:

22 °C, 25 °C and 28 °C.

↓ Radial growth daily measurements for 7 days.

2 | Grain spawn selection →

Fungal strains:

Trametes versicolor
Ganoderma lucidum
Pleurotus ostreatus

Grains:

Millet
Wheat
Millet:Wheat (1:1)

At 25 °C

↓ Linear growth measurements for 15 days.

3 | Wood substrates evaluation

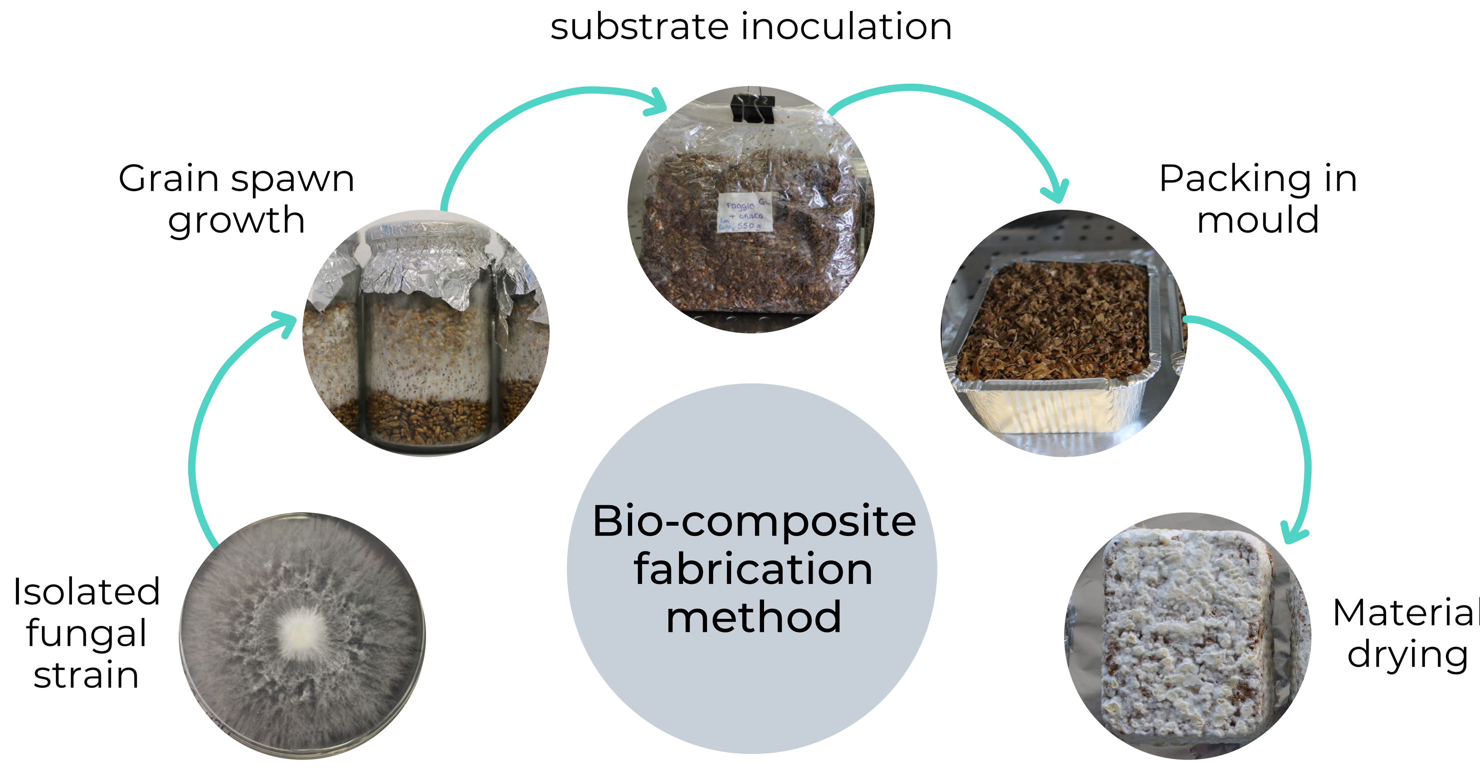
Growth tests using:

Trametes versicolor
Ganoderma lucidum
Pleurotus ostreatus

Wood by-products:

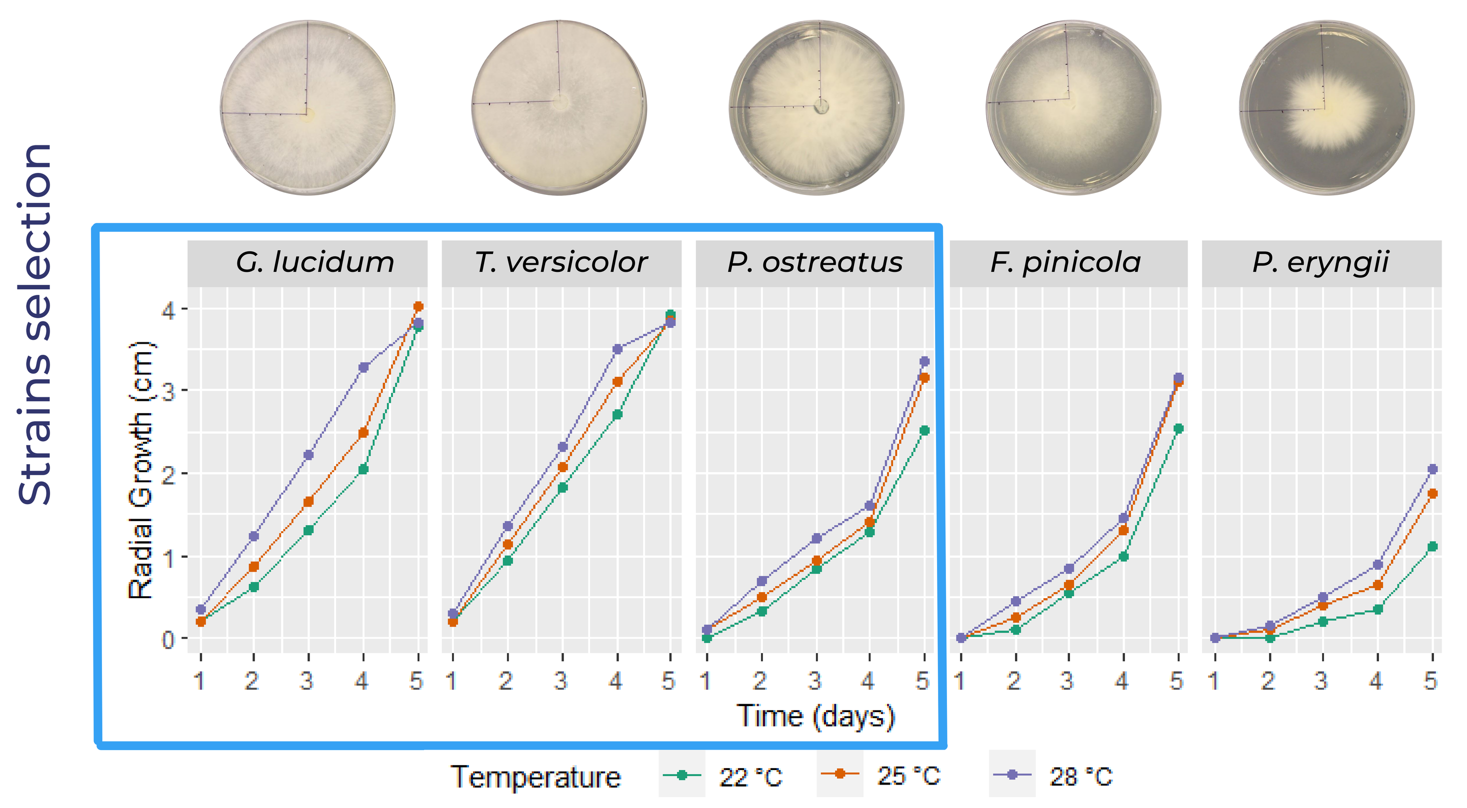
Pine sawdust
Oak shavings
Ailanthus chips
Beechwood

↓ Bulk density measurement and qualitative assessment of the final materials' homogeneity.

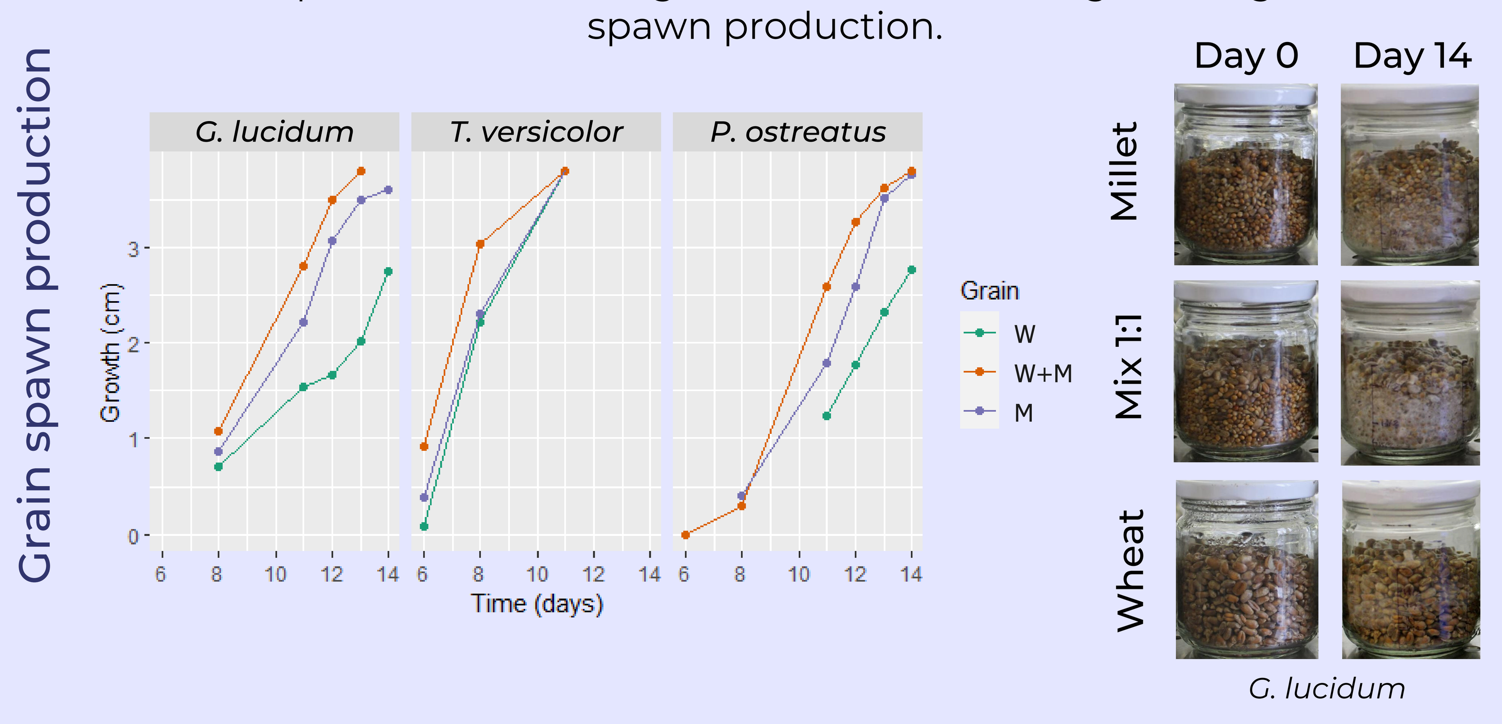


Each arrow represents an incubation period of 5 to 15 days (depending on the fungal strain and step) at 25 °C.

RESULTS AND DISCUSSION



All strains presented a faster growth rate when using mixed grains for spawn production.

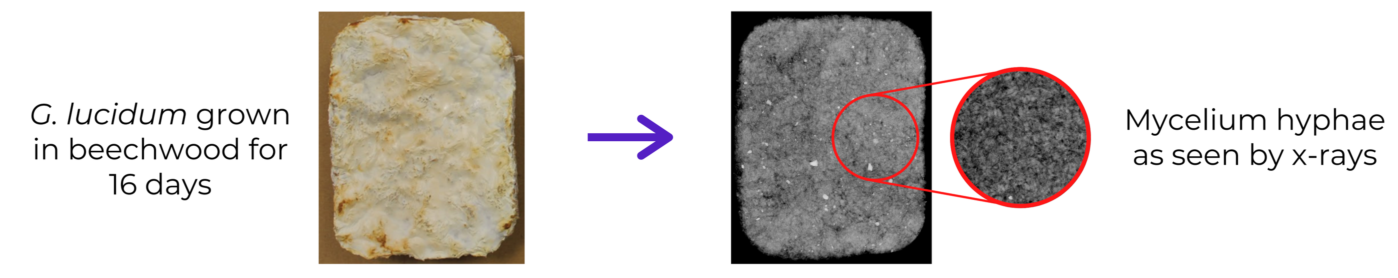


Fibrous substrates resulted in more homogeneous and compact materials, while those that were thinner or chips produced brittle composites that crumbled easily.

Wood substrates evaluation

Table 1. Best wood substrates for mycelium growth (results based on mycelium homogeneity and growth rate).

	G. lucidum	*T. versicolor*	*P. ostreatus*
Best wood substrates	Pine sawdust Beechwood	Oak shavings Pine sawdust	Oak shavings
Mean density (kg/m^3)	240-340	205-240	230-250



The use of substrate mixtures proved to be an interesting alternative, reducing mycelial growth times and improving the homogeneity of the final material.

CONCLUSIONS AND FUTURE WORK

G. lucidum, T. versicolor and *P. ostreatus* grown at 25 °C were chosen due to their fast growth rate and mycelium density. A millet:wheat 1:1 mix was found to be the best option for fungal spawn production. The fastest and more visibly homogeneous bio-composite was obtained when growing *G. lucidum* on beechwood. Nonetheless, mixed substrates demonstrated great potential for substituting pure substrates. Next steps for this research include substrate optimization using mixes and further characterization of the bio-composites including thermal conductivity and humidity resistance tests.

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