PROTOTYPE OF MYCELIUM BASED MATERIAL - A PROSPECTIVE PACKAGING MATERIAL

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College ***:*** *M.S Ramaiah College Of Arts Science And Commerce, Bengaluru*
Branch ***:*** *Microbiology*
Guide(S) ***:*** *Prof. Pushpa H.*
Prof. Savitha J.
Student(S) ***:*** *Ms. Maithri D. B.*
Ms. Sumalatha L.
Ms. Shruthi A. S.

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Introduction

As per conventional definition, fungi are eukaryotic, invariably multicellular, ubiquitous and heterotrophic organisms. A scoop of soil, a millilitre of any type of water bodies, a bit of living, dead animals or plants harbour diverse variety of fungal spores which are capable of emerging as a delicate tuft of cottony cells, the mycelium. This intricate network capable of invading through any substratum is a boon to ecosystem in cycling and recycling nutrients through the food chain by degrading large organic molecules into simpler ones. Undoubtedly, they are the keystone for stabilizing the world ecosystem.

Among the great number of fungi identified so far, only 10% belong to mushroom. The saprophytic mushroom display different characteristics and in general, they have tremendous potential to invade, immobilize and binds the substrate and thereby increasing the strength of the materials formed. Material available in the market for packaging purposes are non-degradable and are consumed at massive amounts and discarded after use leading to environmental hazards like pollution, deforestation causing loss of vegetation and leading to global warming.

The agricultural sector is one of the main sectors generating the largest quantities of agricultural solid wastes, which are generally allowed to accumulate indiscriminately and constitute nuisance to global health and threat to food security. Therefore, recycling of agricultural solid wastes is very important which lead to reduction of greenhouse gas emissions and converted into fossil fuel as well as contributing significantly to the development of new green markets, creation of jobs, production of bio-energy and biodegradable material.

This project will exploit the prolific nature of growth of mushroom fungi on cellulose rich agricultural wastes leading to the formation of sustainable and biodegradable myco-material. These materials will then be designed to form packaging material after thorough evaluation of physical and chemical parameters.

Objectives

1. Standardization of growth of three identified mushroom fungi (from the preliminary work carried out) on various agricultural wastes as solid substrates.
2. Screening the selected fungi with different combination of substrates and evaluation of growth.
3. Optimization of environmental, physical, biochemical and other biological parameters to enhance immobilization of selected fungi on selected solid substrates.
4. Assessment of the resultant material for density, compressive strength, compostability, flame spread, peak heat release rate, smoke emission, thermal conductivity, water vapor permeation, moisture storage at 53.5%, and at 75%, 24 hours water swell, according to ASTM standard.

Methodology:

1. Preparation of agricultural wastes: Agricultural wastes (approximately 20 different wastes and 60 in combinations) were initially cleaned from undesirable material such as pebbles, electrical wires etc., and were shredded into desirable size. In batches, it was soaked overnight and sterilized in an autoclave for 20 minutes. The sterilized substrates were then cooled to room temperature and packed either as single substrate or in combination (in different ratios).
2. Starter culture: Starter culture (inoculum) was used either as spawn or mycelial suspension.

   2.1 Preparation of spawn: Pre-grown culture of selected mushroom fungi was added onto steam-sterilized jowar grain (previously soaked and boiled) and incubated at room temperature for 7 days until profuse growth of the mycelium was visualized. This mycelium mixture is called spawn, and spawn was used as a starter culture.

   2.2 Preparation of mycelial suspension (inoculum): Mycelial suspension was prepared by adding pre-grown mycelial matt, into 10 ml of sterile water and shaken vigorously to break the mycelium into mycelial bits.

   2.3 Preparation of substrate-fungal immobilization: The pre-soaked and sterilized(for 12 hours) substrates (paddy straw, ragi straw, corn cobs, corn straw, etc.,)was overlaid with spawn/mycelial suspension in several layers and then packed tightly in selected plastic boxes of different shapes and sizes (which acts as a mould) and kept for growth at room temperature under dark condition and at desired humidity. The growth of the mycelium was observed at regular intervals until the mycelium grows covering the substrate and forms a perfect desired shape.
3. Mycelial bricks was removed and kept for drying to retard further growth.
4. Environmental parameters (temperature, humidity, pH, moisture content) for immobilization and for the fast growth were assessed.

   The resultant material was assessed for density, compressive strength, compostability, flame spread, peak heat release rate, smoke emission, thermal conductivity, water vapor permeation etc., according to ASTM standard. (US Patent, 20170049059A1, 1971).

Fungal mycelia

Mushroom fungi

Growth of mycelia on solid media

Inoculation of mycelial bits

Growth of mycelia in liquid media

Spawn

Packaging material

Mycelial brick

Result and Conclusion

Three strains of the basidiomycetous fungus were chosen for the primary evaluation of mycelium composite materials based on their capacity to grow more quickly and robustly on particular ligno-cellulosic substrates in varied ratios within the provided mould material.

The mycelial matt that developed in and around the surface produced a layer that was impermeable to water without compromising the material's structure. On both sides of the chosen substrate, mycelial development was seen, exhibiting stiffness, sturdiness and durability.

The environmental issues are coupled to the manufacture and disposable of polystyrene have drawn a lot of attention towards the use of mycelial composites as an alternative to packaging and other industries. It has a possibility as a sustainable and environmentally friendly substitute. The physical and mechanical property have been studied. The composites have significant exceptional mechanical qualities including high strength, low cost, low density, and good thermal induction, so that it makes in use in various industries like packaging, architectural, construction and in textile applications. Mycelial composites are biodegradable so that it degrades fast in environment and doesn't leaves any leftover behind like polystyrene because they are far more environmentally friendly choice.The mycelial composites has denote the mycelial growth parameters, such as temperature, humidity and nutrient availability, thus can be changed to optimize the qualities. This makes to create a unique

qualities that suit a variety of applications. In future studies on this subject may leads to various applications in different industries, but the use of mycelial composites for a sustainable future is promising.

Tests will be conducted on the resultant material's physical characteristics, including its resistance to high temperatures, density, water uptake and long-term impermeability.

Innovation in the project

Demand for sustainable packaging material: The global packaging sector is under increasing pressure to lessen its environmental effect. Mycelial packaging is a biodegradable and sustainable alternative to typical packaging materials. Demand for sustainable packaging solutions is predicted to rise as customers become more ecologically concerned.

Packaging technology innovation: The market is still in its early phases, and there is great room for innovation in the field. As firms continue to engage in research and development, new and inventive applications for mycelial packaging in a variety of industries can be seen.

Collaborations and partnerships: There are great opportunities for collaborations and partnerships between companies in the market. Mycelial packaging, for example, might be used in conjunction with sustainable food production, resulting in a closed-loop system that minimizes waste and has a lower environmental impact.

Overall, the mycelial packaging industry is expected to expand. As more organizations recognize the benefits of this sustainable and environmentally friendly packaging solution. There are huge prospects for organizations operating in this market as demand, innovation, and awareness grow.

Future work scope

The future outlook of the mycelial packaging material market looks promising as more and more companies are realizing the importance of sustainable packaging solutions. Consumers are becoming more environmentally conscious. Moreover, they are opting for and promoting eco-friendly products which are cushioning the market growth.One of the key factors driving the growth of the market is the increasing adoption of circular economy principles by businesses. With the circular economy model, materials are reused and recycled, reducing waste and conserving natural resources. Mycelium-based packaging is a perfect fit for this model, as it is biodegradable, compostable, and can be recycled into new products.

The continuous exploring of new methods to enhance the properties of mycelium-based packaging material leads to the invention of more durable, moisture-resistant, and fire-retardant material. Additionally, there is potential for new applications of mycelium based material in the packaging industry. Besides packaging can be also used as insulation and construction materials.

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