BIOCONVERSION OF AGRO - LIGNOCELLULOSIC WASTE INTO PROTEINACEOUS MASS – A POSITIVE APPROACH (REVIEW)

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ABSTRACT

India is mainly an agricultural country. This fact has been corroborated by the World Bank data, which reveals that India uses 60.3% of its land for agricultural purposes. In addition, the occupation of more than 50% of the citizens depends directly on the various aspects of farming. The agricultural sector generates a major portion of the waste, which is by and large biodegradable. The agro-industries, such as the food processing units, cotton mills, sugar mills, paper mills, textile factories and slaughterhouses (the sewage waste from such units), are the main contributors to the waste production. The biodegradable waste generated is basically lignocellulosic in nature. Generally, these wastes are disposed in the land or are burned. In either manner, it causes pollution (land or air). However, because agricultural waste is natural organic compounds, steps may be undertaken to degrade these products before their release into the environment. Biological degradation, with the help of microbes, is the method of choice. This review deliberates on the breakdown of the lignocellulosic waste with the help of edible mushrooms. This bioremediation method not only produces a proteinaceous food for the masses, but also is responsible for generating employment to many. Furthermore, this technique boosts the usage of mycoremediation technology for pollution control.

KEYWORDS: Lignocellulose, Mushroom & Agricultural Waste

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INTRODUCTION

Worldwide, in today’s scenario, pollution is the main culprit for most of the problems facing the human population. In this review, we are mainly involved in the disposal of lignocellulosic waste produced by the agriculture sector. Several studies have been undertaken to convert the waste into a useful product by treatment and conversion. In addition, steps to reduce the waste production need to be taken. Mycoremediation may prove to be as one successful method. This method employs fungi to fix the pollution issues. These organisms have a versatile nature and are well-known for their capability to degrade solid waste (Rhodes, 2012). Fungi play an important role as degraders in the soil food web.

In point of fact, only fungi can decompose wood. They do so by the vigorous action of the extracellular enzymes and acids, which can degrade the main elements of plant cells (lignin and cellulose). In doing so, the fungal mycelia replenish the soil with nutrients, such as nitrogen, phosphorus, potassium, and other essential inorganic nutrients (Rhodes, 2013). The use of mushrooms (macrofungi) for treatment of lignocellulosic waste is an illustration on mycoremediation.

Mushrooms are employed for bioremediation because of their role in biodegradation, biosorption and bioconversion (Akinyele et al. [2012], Kulshreshtha et al. [2013a]; Kumhomkul and Panich-pat [2013]; Lamrood and Ralegankar [2013]). Different enzymes have been researched for this purpose (Novotný et al. [2004];
Akin yele et al. [2011]; Zhu et al. [2013]), but the ones produced by mushrooms have proven to be the most successful. Pleurotus species of mushroom are one of the popular choices, because of its easy cultivation, adaptation to varied temperature range, and its ability to grow on various substrates, even lignocelluloses (Gogoi and Adhikary, 2002). Furthermore, because these mushrooms are adapted to varied temperatures, their cultivation in the tropical climates of India does not pose a challenge.

Globally, the production of Pleurotus sp. has reached on par with Agaricus bisporus (Lange) Syng. Mushrooms are known to be employed to tackle the degradation of not only lignocelluloses but also various industrial wastes (Singhal et al. [2005]; Dulay et al. [2012] and Aagosh et al 2013). The usage of mushrooms is multibeneficial. It produces protein-rich carpophores (a major vegetarian source of proteins), resolves pollution problems by the direct disposal of lignocellulosic waste, and upholds the usage of mycoremediation for sustainable pollution control.

The Pleurotus mushrooms are known for their medicinal properties. They have a characteristic taste and aroma. They have abundant protein and carbohydrate content, fiber, vitamins and minerals. Antibacterial properties, as well as hypochlosterolemic and immunomodulation activities (Patel et al., 2012), has been reported by these species. In addition, their benefits have been availed in biotechnological and environmental techniques, such as bioconversion of agriculture waste, as animal feed, and biodegradation of organic and industrial pollutants.

Pleurotus sajor-caju (grey oyster mushroom) is more suited for the tropical and subtropical climates, as they are best suited to high temperatures among all the species of Pleurotus. In addition, their cultivation is simple, without the use of any complicated procedures (Chang and Miles, 2004, Kaul and Dhar, 2007).

Prerequisites for cultivation: The mycelium are grown at 10-35°C, with the optimum temperature range of 23-28°C. While fruiting, temperature is set at 18-24°C. The substrate bag/bed is maintained at an optimum pH of 6.8-8.0. The carbon-to-nitrogen ratio in the substrate is 30:60. Proper circulation of air is maintained and adequate light provided to ensure the development of the mushrooms.

<table>
<thead>
<tr>
<th>No.</th>
<th>Substrate</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Composted saw dust</td>
<td>M. Obodai et al., 2002</td>
</tr>
<tr>
<td>2</td>
<td>Wheat straw, soybean straw, and groundnut shells</td>
<td>Mane et al., 2007</td>
</tr>
<tr>
<td>3</td>
<td>Wheat straw</td>
<td>Mandhre et al., 2008</td>
</tr>
<tr>
<td>4</td>
<td>Domestic waste (vegetable biomass from bitter gourd, chilly, cow pea, French bean, and potato)</td>
<td>Ganeshan et al., 1989</td>
</tr>
<tr>
<td>5</td>
<td>Waste paper</td>
<td>Baysal and Parker., 2003</td>
</tr>
<tr>
<td>6</td>
<td>Newspaper and used tea leaves</td>
<td>Jain., 2005</td>
</tr>
<tr>
<td>7</td>
<td>Paddy straw with combination of oil seed rape</td>
<td>Ahmia et al., 2008</td>
</tr>
<tr>
<td>8</td>
<td>Lignocellulosic substrates: conventional viz. wheat straw (WS), paddy straw (PS), and soybean straw (SS); and non-conventional substrates viz. domestic wastes (DW), used tea leaves (UTL), and newspaper waste (NPW) supplemented with soybean bran and groundnut bran</td>
<td>Chandra P. Pokhrel et al., 2013</td>
</tr>
<tr>
<td>9</td>
<td>Maize stalk, pea residue and banana leaves</td>
<td>Shauket et al., 2012</td>
</tr>
<tr>
<td>10</td>
<td>Paddy straw, Wheat straw, Apple leaves, and Chinar leaves</td>
<td>Stanley et al., 2011</td>
</tr>
<tr>
<td>11</td>
<td>Corn cob substrate</td>
<td>Alejandro et al., 2010</td>
</tr>
<tr>
<td>12</td>
<td>Oil mill waste</td>
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</tbody>
</table>

Table 1: Some of the Recent Studies that have Considered Pleurotus Usage for Degradation of Agriculture Waste are Listed in the Table Below
Table 1: Contd.,

<table>
<thead>
<tr>
<th>No.</th>
<th>Substrate Description</th>
<th>Author(s) and Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Leaves and bark of common fruit trees</td>
<td>F C Adesina et al., 2011</td>
</tr>
<tr>
<td>14</td>
<td>Wheat straw, paddy straw, soybean straw, pigeon pea straw and green gram straw</td>
<td>Survase D. M., 2012</td>
</tr>
<tr>
<td>15</td>
<td>Cotton waste</td>
<td>Tan 1981</td>
</tr>
<tr>
<td>16</td>
<td>Cereal bran</td>
<td>Kinugawa 1994</td>
</tr>
<tr>
<td>17</td>
<td>Coffee pulp</td>
<td>Martinez-Carrera (1989); Sanchez et al., (2002); Upadhyay and Sohi (1988)</td>
</tr>
<tr>
<td>18</td>
<td>Corncobs</td>
<td>Heltay (1957); Heltay et al., (1960); Naraian et al. (2009, 2014)</td>
</tr>
</tbody>
</table>

The aforementioned studies have mainly employed forest and agricultural products as the substrate. This study proposes to use lignocellulosic waste. Any lignocellulose material may be used as a substrate, based on its availability, abundance, and cost (Oso 1977a), for the study.

A concise account on the benefits of mushroom cultivation are enumerated as follows:

**Pollution Control and Mushroom Cultivation**

Organic solid waste is produced in large quantities on a daily basis. Agriculture based lignocellulosic waste are a major contributor to it. Lignocelluloses comprise cellulose, hemicellulose, and lignin. These wastes are not utilized by any other industry and are therefore dumped into the environment, where they contribute to the pollution of land, air, and water resources. Mushrooms may provide a solution to this problem, because their hydrolytic and oxidative enzymes have been reported to effectively degrade the lignocelluloses, while simultaneously absorbing them as nutrition. Furthermore, the degraded lignocellulose post cultivation may be employed as compost. This compost is rich in nitrogenous elements, and so may be combined with animal dung or human excreta biogas production. The sludge from the biogas plant is a more efficient biofertilizer. If the biogas is generated in the vicinity of the mushroom house, then it can be used to generate electricity for the pasteurization of the mushroom bed substrate and to maintain optimal cultivation temperatures.

For the rural population, integrated approach to mushroom cultivation, with biofertilizer and biogas production, may have more relevance. This practical approach would generate income in the rural areas, and at the same time help in the successful utilization and disposal of the rural and urban lignocellulosic waste. This concept of multiple end products and complete breakdown of the product is termed as “Zero Emission or Total Productivity.” As it is said, “The earth can not produce more: Man has to do more with what the earth produces” (Pauli, 1996; Chang, 2007), sustainable usage of products complemented with recycling and re-usage is the need of the hour.

Mushroom cultivation may help to generate additional income in the rural sector, especially by the women and the unemployed youth. This secondary income may help to improve their social status. In addition, mushroom cultivation may be successfully done in the winter months and the dry seasons when farming may not be in full-fledged.

Mushrooms serve as a supplementary protein-rich food to the masses. They have significant levels of the essential minerals and vitamins, which have a direct impact on human health. Several bioactive compounds are extracted from medicinal mushrooms and supplied as capsule to improve immunity and the quality of life in humans.
Mycorestoration of the environment: Saprotrophic, endophytic, mycorrhizal, or even parasitic fungi/mushrooms have been reported to restore damaged environments. They may do so by the following varied formats: mycofiltration—fungal mycelia are used as water microfilters; mycoforestry—mycelia restore forests by increasing the organic content, making nutrients available, increasing the retention of water by the soil; mycoremediation—mycelia eliminate toxic waste by degrading them into simpler non-toxic forms; mycopesticides—employing certain exotoxin-producing mycelia to eliminate pests. These methodologies restore the ecosystem without any further damage (Stamets 2005).

CONCLUSIONS

Cultivation of mushrooms supplement food sources and may help to eliminate the shortage of protein-rich food. In addition, they are a good source of nutrients for improvement of human health. Furthermore, mushrooms may help in tackling some of the pollution issues facing humankind. Mushroom biology links food production with sustainable development.

Governments, research centers, and educational institutions play a key role in gathering attention on these important features of mushrooms. They can promote the commercialization of mushroom technology, as well as create awareness for the same. They also need to ensure that all research on this aspect in the laboratory is applied to the fields. Campaigns need to be done so that the farmers may avail of these benefits in technology. Oyster mushrooms can be commercially produced in a cost-effective manner if the substrate used is widely available and cheap. The use of agro waste is, therefore, a very efficient concept. This has been proved both economically and ecologically. However, the availability of suitable substrates varies geographically. Therefore, the farmers need to be trained and provided technical awareness about the various substrates that may be employed in mushroom cultivation. In addition, they need to be taught about the optimization procedures for the various substrates. The endorsement of mushroom cultivation not only helps in generating employment, but also the mushrooms are a source of nutrition. It is a source of revenue for the landless poor and the economically weaker sections of society.

REFERENCES


