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Bioconversion of Agricultural Wastes for Mushroom Production

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Abstract

Agricultural wastes disposal is of foremost concern in today's world because they are rich in nutrient and their disposal without any kind of pre-treatment can cause leaching in field, which can give rise to environmental pollution. To overcome this problem, mushroom cultivation on these agricultural wastes is the most ecofriendly method to reduce the level of nutrients at acceptable range to be used as manure. Mushroom cultivation as a prominent biological process for the valorization of agricultural residues. A large amount of lignocellulosic crop residues is generated annually, rich in organic compounds which are worthy of being recovered and transmuted. India can make rapid progress in mushroom industry by cultivating and commercializing of temperate and tropical mushrooms. But they are still cultivated on small scale in some pockets on a specific substrates and yield potential is not satisfied due to specific substrates materials. In this context, these agricultural wastes can be employed as substrate for the production of mushroom. It not only gives high yield of mushroom in a cost-effective manner but also protect our environment.

Keywords Agricultural wastes, Leaching, Lignocellulosic, Mushroom, Substrate

Introduction

Around 200 billion tons per year of organic matter are produced through the photosynthetic process on the surface of our planet (Zhang, 2008). Moreover, the majority of this organic matter is not directly consumable by humans and animals and, in many cases, becomes a source of various environmental complications. Agricultural wastes are rich in different types of nutrients and their disposal is hard to manage as overabundance of nutrients in them can cause leaching is left in field, as a compost. Mostly they are thrown away by means of incineration which causes ultimately pollution. Recently about 385 million tons of agricultural wastes are available in India and half of these agricultural wastes unused. Even if 1% of this crop residue is utilized in mushroom production that will help in proper residue management and thus, India will become a major mushroom producing country in the world (Tewari and Pandey, 2002). Nevertheless, residues such as cereals straw, corn cobs, cotton stalks, various grasses and reed stems, maize and sorghum stover, vine prunings, sugarcane and tequila bagasse, residues of coconut and banana, corn husks, pulp and husk of coffee, cotton seed and sunflower seed hulls, peanut shells, rice husks, sunflower seed hulls, waste paper, wood sawdust are some examples of residues and by-products that can be recovered and upgraded to higher value and useful products by chemical or biological processes (Webb *et al.*, 2004). In this context the mushroom cultivation represents one of the economically viable processes for the bioconversion of agricultural wastes in to protein rich food making it a powerful weapon against malnutrition which is most frequently found in developing countries like India.

Food and Nutritional Value of Mushrooms

Mushrooms were believed by the Greeks to give strength to the warriors while Romans regarded them as the 'Food of the Gods'. The Chinese prized mushrooms as health food, the 'elixir of life' etc. In developing countries like India, malnutrition is one of the major problems because most of the population falls below the economic line. Mushrooms are considered to be healthy food as they have relatively high qualitative good protein, minerals and low-fat content (Table 1).

Table 1: Proximate composition (Per cent fresh weight) of the cultivated mushrooms (Rai and Sohi, 1988)

Mushroom	Moisture	Protein	Fat	Carbohydrate	Fibre	Ash	Calorie
Agaricus bisporus	90.1	2.9	0.3	5.2	0.9	0.8	36
Pleurotous sajor-caju	90.2	2.5	0.2	5.0	1.3	0.6	35
Volvariella volvacea	90.1	2.1	1.0	4.7	1.1	1.0	36

Mushroom Cultivation

Mushrooms are fleshly fungi, spore bearing fruiting bodies which are produced on above ground soil. They frequently refer to fruiting body of the gill fungi, which do not contain chlorophyll like green plants and that's why cannot able to produce food by their own. They are so much nutritious product that can be generated from lignocellulosic waste materials. Mushrooms have been not only used for

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food and medicine but also have often been considered a sumptuous food reserved for the elite. The bioconversion of agricultural wastes into a value-added product is a viable way of their utilization. Small or large-scale commercial mushroom production is an efficient and relatively short biological process for recovery of food protein from negative value lignocellulosic materials, by using the degrading capabilities of mushroom (Chiu and Moore, 2001). Their mycelium can produce sufficient amount of a plethora of enzymes, which can degrade lignocellulosic residues and then use them as a source of nutrients for their growth and fructification (Elisashvili *et al.*, 2008). Now, the farming system has been changed in the period of last 21st century and farmers taking an interest in modern cultivation techniques to get the maximum per capita income. Therefore, mushroom cultivation is a potential alternative for them. There are mainly three stages involved in mushroom cultivation: (1) inoculum (spawn) production, (2) substrate preparation, and (3) mushroom growing i.e., inoculation of the substrate along with propagules, growth of the fungal mycelium to colonize the substrate, followed by fruiting, harvesting and processing of the fruiting bodies. Different types of agricultural waste that can used alone or in with combination for mushroom cultivation (Table 2 & 3)

Table 2: Various types of agricultural wastes used for mushroom cultivation (Elahe *et al.*, 2016)

Agricultural wastes	Strain
Rice straw, Wheat straw, Cotton straw, Tea leaves, Banana leaves	*Pleurotus sp.*
Wheat straw	*Agaricus bisporus*
Rice bran, Coffee pulp	*Lentinula edodes*
Sawdust	*Ganoderma sp.*

Table 3: Combination of substrates reported on various strains (Elahe *et al*., 2016)

Substrate (in combination)	Strain
Barley straw+wheat bran and wood chips+soybean powder+rice bran treatments	*Pleurotus eryngii*
Wheat straw+wheat bran+soybean powder treatment	*Pleurotus eryngii*
soybean straw+wheat straw	*Pleurotus sajorcaju*
soybean straw+saw dust	*Pleurotus sajorcaju*
corncob +sugarcane bagasse	*Pleurotus ostreatus* *Pleurotus cystidiosus*

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Effect of Agricultural Wastes Composition with Mushroom Cultivation

Banana stalk and Bahia grass are used for the cultivation of *Pleurotus sajor-caju* with biological efficiency of 74.4% and 74.12% respectively but there is a low yield when they are supplemented with other components. This may be due to high nitrogen concentration which hampers its yield (Thongklang and Luangharn, 2016). Growth of *Pleurotus ostreaus* resulted similar in paddy straw and wheat straw but in sugarcane bagasse it resulted in low yield. Reason behind this selective high yield must be appropriate concentration of lignin, hemicelluloses, cellulose in substrate (Elahe *et al*., 2016). There is a positive correlation of cellulose lignin ratio with mycelia growth and high yield in *Pleurotus ostreatus* and carbon nitrogen ratio with mushroom yield in *Pleurotus eryngii* and *Agaricus aegerita* while in *V. volvacea* strains high yield is related to cellulose content (Ralph & Kurtzma, 1994). Vegetable waste when used in combination with paddy straw resulted in high yield of oyster mushroom (Poonam and Deepak, 2013). To cultivate *P. ostreatus* sawdust in addition to rice husks is reported as an optimal substrate (Singh & Singh, 2012) The quality of *P. eryngii* was significantly affected by substrate ingredients. On barley straw and sugar beet pulp substrate complemented with rice bran, highest mushroom fresh weight and moisture content were achieved (Zadrail & Dube, 1992). For Pleurotus sajor-caju, combination of soybean straw, wheat straw showed significantly highest yield while soybean straw and saw dust combination showed significantly lesser yield (Rani *et al*., 2008). It is evident from the data (Table 4) on yield performance with various utilized substrates. The substrate of paddy straw was found significantly superior than other substrates by producing (955.66 gm/bag). The mixture of paddy straw + wheat straw was second best substrate where it produced (893.66 gm) mushroom/bag followed by wheat straw (793.67 gm), mixture of wheat straw + chapped leaves of sorghum (584.33 gm) and mixture of mixture of saw dust + wheat straw (535.33 gm). Thus, paddy straw was best substrate for the cultivation of the milky mushroom (*Calocybe indica*) because it was given better yield and good quality than the other substrate.

Biological efficiency (BE) expresses the bioconversion of dry substrate to fresh fruiting bodies and indicates the fructification ability of the fungus utilizing the substrate (Fan *et al*., 2000). BE is determined the rate proportion of the fresh weight of harvested mushrooms over the weight of dry substrate at inoculation. Sawdust had the highest biological efficiency of 60.1% and lowest value of 14% obtained in maize cobs. Among the supplemented substrates, maize stalk gave the maximum biological efficiency of 39.2% followed by maize husk. Maize cobs recorded the lowest biological efficiency of 9.5% (Figure 1).

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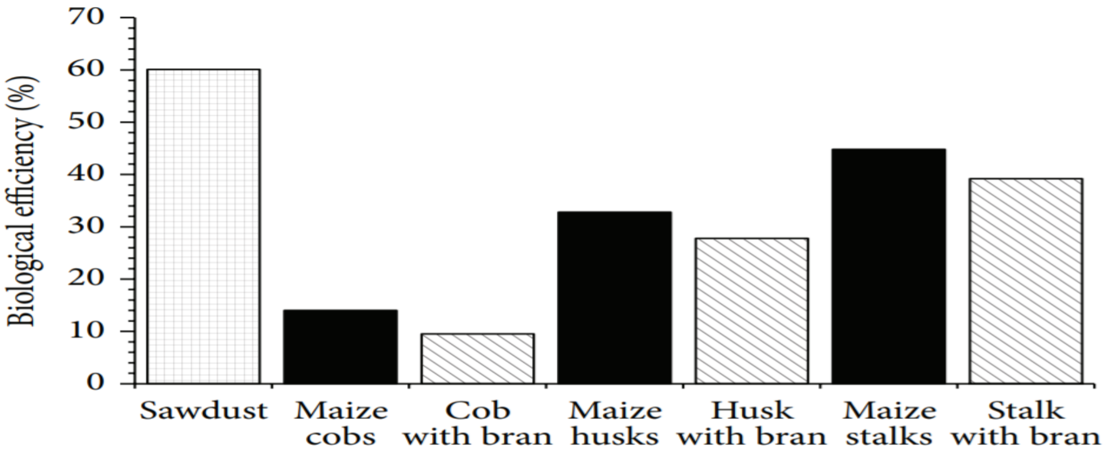
Table 4: Effect of substrates on growth parameters of milky mushroom (*Calocybe indica*) (Kumar and Chandra, 2013)

Treatment	Cap diameter(cm)	Stalk length (cm)	No. of fruiting bodies per bag	Yield of 1st flush (gm)	Yield of 2nd flush (gm)	Total yield (gm)
Paddy Straw	7.13	8.67	14.00	523.33	432.33	955.66
Wheat Straw + Paddy Straw (1:1)	6.83	7.83	10.83	483.33	410.33	893.66
Wheat Straw	6.50	7.33	10.67	407.67	386.00	793.67
Wheat Straw + Chapped leaves of sorghum(1:1)	5.62	7.60	9.00	314.33	275.00	589.33
Saw dust + wheat straw (1:1)	5.33	7.00	7.67	288.67	246.67	535.33
SEm$_{\pm}$	0.41	0.52	1.19	20.67	26.65	-
CD(P=0.05)	1.31	1.62	3.75	65.13	83.96	-

Figure 1: Biological efficiency (BE) of sawdust and maize residues. (1) Biological efficiency (BE) was a function of substrate usage to amount converted into harvested mushroom. (2) Substrates with bran contain 8.4% rice bran (Abena *et al.*, 2015)



Conclusion

In the present scenario proper waste management and execution of waste disposal practices are of our prime concern. The exponential expansion in the present amount of waste produced brings to see a quick necessity of solution to overcome this issue. Mushroom cultivation is the most suitable technology for generation of wealth and health out of wastes from plants, animals and industries which are bounteously available on earth. Huge quantities of agricultural wastes and other organic wastes are produced annually through the activities of agriculture, forest and food processing industries. These agricultural wastes and other organic wastes are abundantly available in our country. The major parts of these agricultural wastes are burnt after harvesting, resulting multifaceted hazards including oxygen defiant environment, respiratory diseases such as allergic, bronchitis, asthama, tuberculosis and poor visibility at night. The beneficial insects, bio-agents, earthworms and soil microbes are also declined due to burning of agricultural wastes. Mushroom production represented an attractive method of improving the nutritional quality of lignocellulosic wastes for use as an animal feed stock. Among the various physical, chemical and biological methods are being used for upgradation of the digestibility and nutritive value of agricultural wastes, biodegradation by using white rot fungi including mushrooms have been found most effective. Even after using it in mushroom cultivation, can also be used as manure for agricultural field as a source of nutrients. Cultivation of mushroom on various residual wastes is one of the eco-friendly practices to combat the malnutrition and environmental pollution caused by these agricultural wastes. There is need to evaluate various substrates for enhancing better growth behaviour and yield potential of mushrooms. Various researches are still going on to exploit the potential of agricultural wastes either by using them in combination or by giving them pre-treatment.

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