International Journal of Botany Studies
www.botanyjournals.com
ISSN: 2455-541X
Received: 20-04-2024, Accepted: 12-05-2024, Published: 06-06-2024
Volume 9, Issue 6, 2024, Page No. 5-8

Agro-waste is not a waste: A way to mushroom farming, a sustainable approach

Manmohan Arya
Department of Botany, University of Rajasthan, Rajasthan, India

Abstract
Agro-waste is a product which comes out during crop cultivation process. Today we are dealing with many environmental issues related to agro-waste disposal and ultimately pollution. Despite having disposal issues, this agro-waste is rich in important nutrients. In India, Rabi, Kharif and Zaid crops like rice, wheat, millets and oilseed crops are grown according to their seasonal requirements. Agro-waste is produced in abundance from these crops, which create disposal problem. Agro-waste generally found in residual form, which may be divided into stem, leaf, stalks, branch, stubble, husk, shell, cobs, cakes, peels form. Cellulose, hemicellulose and lignin are main components of agro-waste. At some extent agro-wastes are used as fodder, however its use in traditional agriculture is limited. On the other hand, mushroom can utilize lignocellulosic waste for their own growth due to their degradation and absorption capabilities. Mushroom utilizes agro-waste nutrients and modify them in edible form. There are various types of edible mushrooms found naturally, including species from the genera *Pleurotus*, *Agaricus*, *Volvoriella*, *Calocybe*, and *Lentinula*. Thus, the appropriate application of agricultural waste for mushroom cultivation has advantage over its general disposal. Additionally, combination of agro-wastes is found more suitable for edible mushroom's growth. Therefore, the use of agro-waste for mushroom cultivation offers a sustainable agricultural cost-effective approach with multiple benefits.

Keywords: Environmental issue, lignocellulosic waste, disposal problem, mushroom cultivation

Introduction

Agro-waste is a product who comes out after crop thrashing process during harvesting. It has a little use to farmers. They burnt it or left in the farm fields. It creates lots of environmental problems. Cycling of materials is necessary for smooth functioning of ecosystem. Our ancient agricultural practices provide a path to achieve sustainable development goals. Mushroom takes its nutrition from plant-waste which contains lignin, cellulose and hemicellulose. Agro-industrial biomass which contains lignocellulose is abundant, renewable and provides a wonderful resource for generation of bioenergy (Kosre *et al.*, 2021) [12]. Mushroom contains some enzymes to degrade such type of hard substances. Edible and non-edible categories of mushrooms are found on earth. Edible ones are natural growing or cultivable. Wheat, rice, cotton, mustard, groundnut, jowar, bajra, and sugarcane are the main agricultural crops. Leaves of banana and tea plantations are also useful. Therefore, we receive waste from numerous crops. Most wastes can be utilized as in the form of straw. Agricultural waste comes out from cultivation, may solid or liquid in nature. There are issues with how to dispose of these crop remnants or post-harvest garbage. Health, environment, safety concerns related to them can be seen now a days. By the use of agro-waste to produce biofertilizer is a cost-effective method (Lim and Matu, 2015) [14]. Agro-wastes are rich in nutrients, but when they are disposed of, they cause significant environmental issues. If waste is managed properly, it can be stopped from leaching on the field and transformed into compost. Disposal of farm waste through burning creates pollution The digestate material from biogas plant along with agricultural waste from paddy straw and coir pith was used as substrates for the production of *Pleurotus florida* (Udayasimha and Vijayalakshmi, 2012) [21]. *Pleurotus sajor-caju* (Fr.) Singer was cultivated on various agro-wastes such as wheat straw, black gram straw, okra straw, maize straw and maize hulled cobs. Yield performance was observed in oyster mushroom (Kumar, 2020) [13]. Agro-wastes are burnt by farmers in fields which is a soft and cheap way of agro-waste disposal, but this has a deleterious impact on the agricultural ecosphere. different agricultural waste materials, like wheat straw, rice straw and cotton waste were used for the cultivation of milky mushroom (Sardar *et al.*, 2020) [19]. Food crops (rice, pulses, millets, maize, wheat), cash crops (cotton, tea, coffee, oil seeds, jute, sugarcane), plantation crops (tea, coffee, rubber and coconut) and horticulture crops (vegetables and fruits) are main categories into which waste from various crops are categorised.

Agro-waste in India

Temperate, tropical and subtropical regions are found in the Indian subcontinent. So eminent biodiversity can be noticed in this country. Northern Himalayas to southern coastal region, eastern dense forest to western desert part, shows various changes in temperature and rainfall. This leads to soil formation and texture, accordingly crops diversity. Depending on their utility, crops are separated into food crops and cash crops. Food crops are part of daily life directly. Primarily, food crops are included in the Poaceae and Fabaceae families. Wheat, rice, maize, bajra, and pulses are examples of food crops. Exporting or selling cash crops generates income for us. Cotton, tea, coffee, groundnut, mustard, sugarcane, jute, and guar are examples of cash crops.

Agro-waste availability can be seen in different Indian states. Agro-waste producing crops belongs to limited families of plantae group. Specific crop season belongs to crop production. Rabi, Kharif and Zaid, three main crop growing seasons are observed in India. The various agro-waste available in different state of India is summarised in table 1.

Table 1: Production of agro-waste in different Indian states

Agro-waste producing crops	Family	Crop Season	Availability in State
Food Crops			
Bajra, Jowar	Poaceae	Kharif	Rajasthan, Uttar Pradesh, Haryana
Rice	Poaceae	Kharif	Bengal, Uttar Pradesh, Punjab
Pulses	Fabaceae	Kharif	Madhya Pradesh, Rajasthan, Maharashtra
Maize	Poaceae	Kharif	Karnataka, Madhya Pradesh, Maharashtra
Wheat	Poaceae	Rabi	Uttar Pradesh, Madhya Pradesh, Punjab
Soyabean	Fabaceae	Kharif	Maharashtra, Madhya Pradesh, Rajasthan
Cash Crops			
Cotton	Malvaceae	Kharif	Gujrat, Maharashtra, Rajasthan
Tea	Theaceae	Kharif	Assam, West Bengal, Tamil Nadu
Coffee	Rubiaceae	Kharif	Karnataka, Kerala, Tamil Nadu
Mustard & Rapeseed	Brassicaceae	Rabi	Uttar Pradesh, Rajasthan, Madhya Pradesh
Groundnut	Fabaceae	Kharif	Gujrat, Rajasthan, Tamil Nadu
Jute	Malvaceae	Kharif	West Bengal, Bihar, Assam
Sugarcane	Poaceae	Zaid	Uttar Pradesh, Maharashtra, Tamil Nadu
Guar	Fabaceae	Kharif	Rajasthan, Haryana, Gujrat

Rajasthan is the largest state of the country. This state can be divided into northern, southern, eastern and western parts. Various climatic regions are found here. Crop diversity is a beautiful feature of this land. Therefore, different type of crops waste is available here. Mainly, agro-waste comes from Rabi and Kharif crops. The agro-waste producing Kharif and Rabi crops in different part of Rajasthan is summarised in table 2.

Table 2: Crops waste available throughout Rajasthan state in different seasons

Regions	Kharif crops waste from	Rabi crops waste from
Northern	Rice, Cotton, Sugarcane,	Wheat, Barley, Mustard, Rapeseed
Southern	Maize, Small Millets, Urad, Soyabean	Masoor, Linseed
Eastern	Groundnut, Mustard, Sunn hemp	Matar, Mustard, Rapeseed
Western	Bajra, Jowar, Guar, Moong, Moth bean, Castor seeds	Small Millets, Gram, Linseed

Crop's residual part can be used as substrate in mushroom cultivation. Residues are of two types post-harvesting residue and post-processing from agriculture waste. Collection of wastes is to be made in different months of the year. Various parts of crops are useful in different ways. Table 3 and figure 1 show main Indian crops with their residues.

Table 3: Indian crops and their residues (Major types)

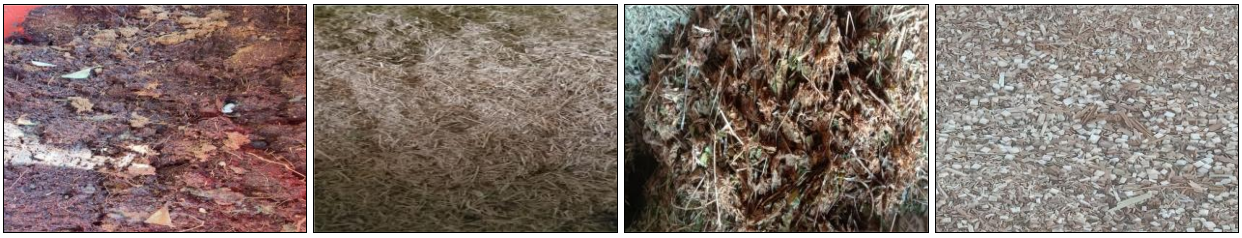
Indian crops	Harvesting months	Post-harvesting residues	Post-processing residues
Rice	Sept-Oct.	Straw, Leaves and Stubble,	Husk
Wheat	Feb-Apr.	Straw, Leaves and Stubble	Pod/Panicle
Bajra	Sept-Oct.	Stalks	Husk, Cobs
Jowar	Sept-Oct.	Stalks	Husk, Cobs
Guar	Oct-Nov.	Stalks, Leaves	Husk, Shell
Sugarcane	Oct-May	Tops and Leaves	Bagasse
Maize	Sept-Oct.	Stalks (Stem)	Cobs
Banana	Year Round	Leaves, Pseudo stem	Pith, Peels of fruits
Mustard	Feb-Apr.	Stalks	Husk,
Coconut	Year Round	Fruit brunch and Fronds	Coir, Pith, Shells
Groundnut	June-Oct.	Stalks	Shell
Areca nut	Aug-Jan.	Fruit brunch and Fronds	Husk
Castor	Dec-Jan.	Stalks and Leaves	Husk, Press cakes
Soybean	Oct-Nov; Jan-Feb.	Stalks	N.A.

Brassica campestris

Cyamopsis tetragonoloba

Arachis hypogaea

Triticum aestivum



Cocos nucifera ***Cicer arietinum*** ***Vigna aconitifolia*** ***Pennisetum typhoideum***

Fig 1: Agro-wastes from various important crops after post-harvesting stage. Plants species wastes shown in figure are *Brassica campestris* (Mustard), *Cyamopsis tetragonoloba* (Guar), *Arachis hypogaea* (Groundnut), *Triticum aestivum* (Wheat), *Cocos nucifera* (Coconut), *Cicer arietinum* (Gram), *Vigna aconitifolia* (Moth bean), *Pennisetum typhoideum* (Bajra)

Main agro-wastes are obtained from paddy, wheat, mustard, soyabean, sugarcane, maize, coconut, banana, groundnut, guar, bajra, jowar. Straw and husk in paddy; straw in wheat; stalk in mustard; husk in soyabean; bagasse, tops and leaves in sugarcane; coconut coir and shell; banana pseudo stem; groundnut shell is part of importance. Lignocellulose is important constituent of plants waste. According to many researchers, various plants and their part shows variability in lignin, cellulose and hemicellulose content. Lignocellulosic content of some crops is shown below in a table 4.

Table 4: Lignocellulose contents of various Indian agro-wastes

Agro-waste	Lignin (%)	Cellulose (%)	Hemicellulose (%)	Source
Paddy straw	17.00	42.00	22.00	Cardeon *et al*. (2015)
Paddy husk	24.60	43.80	31.60	Kataki *et al*. (2015) [11]
Wheat straw	13.00	42.00	30.00	Cardeon *et al*. (2015)
Mustard stalks	2.20	39.50	18.70	Raj *et al*. (2015) [18]
Soybean husk	9.88	33.49	17.15	Brijwani and Vadlani (2011) [3]
Sugarcane bagasse	13.40	58.20	9.20	Cardeon *et al*. (2015)
Sugarcane leaves	22.70	40.80	28.70	Franco *et al*. (2013) [9]
Sugarcane tops	21.70	39.70	32.00	Franco *et al*. (2013) [9]
Coconut coir	17.80	47.70	25.90	Chowdhury *et al*. (2018) [5]
Coconut shell	28.70	36.30	25.10	Chowdhury *et al*. (2018) [5]
Banana pseudo-stem	8.07	44.00	18.40	Fernandes *et al*. (2012) [8]
Groundnut shell	30.20	35.70	18.70	Chowdhury *et al*. (2018) [5]

Management of Agro-waste

Now, need of the hour is to develop cost effective procedure of waste management which should be environment friendly. Mushroom cultivation could utilize the nutrients from these agro-wastes and minimize its deleterious effects. Seven mushroom species have been evaluated for their growth capacity on agro-waste mixed with different formulations (Nicolcioiu *et al*., 2016) [15]. Lignocellulose based agriculture thrash out products breakdown is big task but it is easily and effectively done via mushroom cultivation. Physicochemical and nutritional contents can enhance using white-rot fungi in biological treatment of agricultural waste products. It can be further used as animal feed (Nwafor *et al.*, 2022) [16]. Mushrooms bears fruiting bodies in the form of basidiocarp containing spores. Fleshy fungi grow above ground level. Mushrooms are useful form of converted lignocellulosic waste, having nutritious and medicinal quality. The best part of mushroom cultivation is bioconversion capacity of fungi which convert agriculture waste into useful products (Quimio,1978; Bano and Rajarathanam,1982; Tan and Wahab, 1997; Bonatti *et al*., 2004) [1, 2, 17, 20].

Main component of agro-waste is lignin and cellulose. Breakdown of these components are tough. These insoluble substances are out of reach to bacterial decomposition in soil area. Mushroom has enzymes for degradation. So, these extracellular enzymes are very useful in degradation processes. The unique feature of edible fungi is conversion capacity of complex compounds to simpler one by which useless agro-waste converted into valuable products. Farming of different mushroom species can be observed across globe. *Agaricus*, *Pleurotus*, *Volvoriella*, *Calocybe*, *Lentinula* are main mushroom genus which are cultivated in India. Mostly edible and cultivable mushrooms belong to basidiomycetes group of fungi. White button prefers the temperate zone while oyster and paddy straw mushrooms grow in subtropical climates. *Morchella* and *Tuber* spp. are found in temperate climate. Some edible mushroom species are shown in table 5.

Table 5: Edible mushroom presence in different part of the world

Mushroom	Common name	Climatic region	World region	Fungal class
Agaricus bisporous	White button/cremini	Temperate	China, Eurasia, North America	Basidiomycetes
Pleurotus species	Oyster/dhingri	Sub-tropical	China, other Asian counties	Basidiomycetes
Volvoriella species	Paddy straw mushroom	Subtropical, Tropical	East & South East Asia	Basidiomycetes
Lentinula edodes	Shiitake	Year round	South East Asia	Basidiomycetes
Calocybe indica	Milky/summer mushroom	Tropical	Vietnam, Equatorial	Basidiomycetes
Morchella esculenta	Yellow mushroom/gucchi	Temperate	China, Woodlands	Ascomycetes Morel/sponge
Tuber melanosporum	Black truffle	Temperate	China, Italy, Spain, France	Ascomycetes, Tuberaceae

Mushroom cultivation is a way to overcome wastes problem mainly in agro-sector. Cultivable species selection depends upon available waste criteria. Mushroom cultivation using agro-wastes is an economic and environmentally friendly approach to maintain healthy ecosystem (Dhiman *et al.*, 2022) [6]. *Pleurotus* species are easiest to grow because they can grow on many substrates. *Pleurotus* has versatile adaptability regarding substrates whereas *Agaricus* cultivation is restricted to wheat straw mainly. Disinfection of substrates should be done primarily. If straw already bears microbes is not suitable for mycelium growth because microbes are tiny competitors of mushroom spores. Optimum presence of cellulose, lignin, hemicellulose in mushroom growing material provides high yield. *Pleurotus eryngii* cultivates on lignocellulosic waste like wheat straw and wood chips gives a high yield and also bears many medicinal and nutritional contents with long shelf life (Elahe *et al*., 2016) [7]. Mushrooms take its nutrition from different cereal straws which contains lignin, cellulose and hemicellulose. Supplementation plays important role in better outcome in mushroom cultivation process. If main substrate is supplemented with nutrients or combination of substrate were results in higher yield of *P. sajor-caju* (Jadhav *et al*.,1998) [10]. Supplements play important role in substrate capacity enhancement. Urea, lime, gypsum are such supplements which are used.

Conclusion

There is an opportunity to do economic farming due to availability in plenty of plant and agro-waste in the country. Mushroom farming shows sustainable approach. It can be considered as an eco-friendly practise because it consumes agriculture wastes and gives nutrient rich mushroom production. Fight against malnutrition as well as pollution is carried out by utilisation of agro-waste through mushroom farming. Many researchers are focusing on potential use of agro-wastes. Waste combinations are being tested for improved output. Impact of treatments are also viewing in mushroom yield enhancement. Thus, we may conclude that agro-waste is not a waste. Agro-waste-dependent mushroom cultivation is a futuristic practice meeting sustainable developmental goals.

References

1. Bano Z, Rajarathanam S. Studies on the Cultivation of *Pleurotus sajor-caju*. The Mushroom Journal,1982:115: 243-245.
2. Bonatti M, Karnoppa P, Soaresb HM, Furlana SA. Evaluation of *Pleurotus ostreatus* and *Pleurotus sajor-caju* Nutritional Characteristics When Cultivated In Different Lignocellulosic Wastes. Food Chem.,2004:88: 425-428.
3. Brijwani K, Vadlani PV. Solid state fermentation of soybean hulls for cellulolytic enzymes production. Soybean-Appl Technol., 2011.
4. Cardoen D, Joshi P, Diels L, Sarma PM, Pant D. Agriculture biomass in India: Part 1. estimation and characterization. Resour Conserv Recycl,2015:102:39–48.
5. Chowdhury R, Ghosh S, Debnath B, Manna D. Indian Agro-wastes for 2G Biorefineries: Strategic Decision on Conversion Processes. Chapter in Green Energy and Technology, 2018.
6. Dhiman VK, Singh D, Pandey H, Chauhan D, Dhiman VK, Pandey D. Myco-remediation of agricultural waste for the cultivation of edible mushroom. In Sustainable management of environmental contaminants: eco-friendly remediation approaches. Cham: Springer International Publishing, 2022, 471-482.
7. Elahe KJ, Mehrdad J, Shahin E. King oyster mushroom production using various sources of agricultural wastes in Iran. International J Rec Org Waste Agricul,2016:5:17-24.
8. Fernandes E, Marangoni C, Medeiros S. Slow Pyrolysis of Banana Culture Waste: Leaves and Pseudo-stem. The 3rd International Conference on Industrial and Hazardous Waste Management, Crete, 2012, 453-456.
9. Franco HCJ, Pimenta MTB, Carvalho JLN, Magalhães PS, Rossell CEV, Braunbeck OA, *et al*. Assessment of sugarcane trash for agronomic and energy purposes in Brazil. Scientia Agricola,2013:70(5):305–312.
10. Jadhav AB, Bagal PK, Jadhav SW. Biochemical changes in different agro residue to oyster mushroom cultivation. J. Maharashtra Agric. Univ.,1998:23(1):22–24.
11. Kataki R, Chutia RS, Mishra M, Bordoloi N, Saikia R, Bhaskar T. Feedstock suitability for thermochemical processes, 2015.
12. Kosre A, Koreti D, Mahish PK, Chandrawanshi NK. Current perspective of sustainable utilization of agro waste and biotransformation of energy in mushroom. Energy: crises, challenges and solutions, 2021, 274-302.
13. Kumar P. Effect of Different Agro-Waste Substrates on Yield Performance of Oyster Mushroom (*Pleurotus sajor-caju*). J. krishi vigyan,2020:8(2):70-74.
14. Lim SF, Matu SU. Utilization of agro-wastes to produce biofertilizer. International Journal of Int. J. Energy Environ. Eng.,2015:6:31-35.
15. Nicolcioiu MB, Popa G, Matei F. Mushroom Mycelia Cultivation on Different Agricultural Waste Substrates. Romania Scientific Bulletin Series F. Biotechnologies, 2016, Xx.
16. Nwafor SO, Adenipekun CO, Aruwa G, Asemoloye M. D. Biotreatment of selected agrowaste products with some culinary-medicinal mushrooms enhances their nutrient composition for use as animal feed in Nigeria. Int. J. Med. Mushrooms, 2022, 24(6).
17. Quimio TH. Introducing *Pleurotus flabellatus* for Your Dinner Table. Mushroom J.,1978:69:282-283.
18. Raj T, Kapoor M, Gaur R, Christopher J, Lamba B, Tuli DK, *et al*. Physical and chemical characterization of various Indian agriculture residues for biofuels production. Energy Fuels,2015:29(5):3111–3118.
19. Sardar H, Anjum MA, Nawaz A, Naz S, Ejaz S, Ali S, *et al*. Effect of different agro-wastes, casing materials and supplements on the growth, yield and nutrition of milky mushroom (*Calocybe indica*). Folia Horticulturae,2020:32(1):115-124.
20. Tan YH, Wahab MN. Extracellular Enzyme Production during Anamorphic Growth in the Edible Mushroom, *Pleurotus sajor-caju*. W Micro Biotech,1997:13:613-617.
21. Udayasimha L, Vijayalakshmi YC. Sustainable Waste Management By Growing Mushroom (*Pleurotus florida*) On Anaerobically Digested Waste and Agro Residues. Int J Eng Res Tech,2012:1:12.