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Growth performance and nutrient content analysis of two *Volvariella* species cultivated on rice straw substrate

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Abstract

Mushrooms possess the capacity to break down and transform various agricultural byproducts into useful materials. The application of mycelial technologies in mushroom cultivation can aid in reducing environmental contamination through bioconversion processes that turn unwanted materials into nutritious food sources by properly processing and reusing spent substrates. Research indicates that more than 70% of agricultural and forestry products are not fully utilized and end up as waste. Mushrooms can transform this substantial ligno-cellulosic biomass waste into edible protein sources. This research investigates the biological efficiency of two *Volvariella* species cultivated on rice straw substrate. Growing edible fungi, specifically *Volvariella volvaceae* and *Volvariella diplasia*, presents a potential answer to insufficient regional food supplies, declining health standards, and increasing environmental degradation. This study aimed to assess the bioefficiency and bioconversion of these two species grown on rice straw as a growth medium. The biological efficiency was determined by calculating the ratio of fresh mushroom weight to air-dry substrate weight. This research also computes the conversion of dry compost to fruiting bodies in *Volvariella* species cultivated on rice straw. The findings of this study showcase the potential of mushroom cultivation to provide an affordable, high-quality protein food source while simultaneously reducing environmental pollution through the bioconversion of agricultural waste products such as rice straw.

Keywords: Mushroom; *Volvariella*; Bioefficiency; Bioconversion; Rice straw; Substrate

1. Introduction

Three essential challenges affect worldwide wellbeing: regional food scarcity, poor health conditions, and environmental degradation. The world population increase will worsen the scale of these challenges. Researchers in mushroom biology develop a practical approach by making nutritious food proteins at affordable costs. The new food category of mushrooms is expanding quickly as more health-conscious people choose to eat these nutritious food.. Mushroom biology offer partial but meaningful solutions for this problem through the generation of relatively cheap source high quality food protein. Mushrooms constitute a most rapidly growing new food category which the current health oriented public is increasingly enjoying .Wastes such as cereal straws are largely burnt by the farmers, which causes air pollution. These unprocessed materials hold great promise as a resource for mushroom cultivation. Bioconversion methods help us to reduce pollution in the environment. Mushroom cultivation provides quick returns for farmers and helps communities right now through the production of straw mushrooms called *Volvariella volvaceae* (Bull.)Singer. Mushrooms of the genus *Volvariella* are known for their nutritional value and economic importance in many parts of the world. These fungi are rich in proteins, essential amino acids, vitamins, and minerals, making them a valuable food source in many cultures. *Volvariella* species are particularly popular in Asian cuisines, where they are prized for their delicate flavor and tender texture. Their cultivation has become an important agricultural practice in several countries, contributing significantly to local economies and providing a sustainable source of income for many

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farmers. The economic importance of *Volvariella* mushrooms extends beyond their role as a food crop. Their cultivation requires relatively simple techniques and can be carried out using agricultural waste products, such as rice straw or cotton waste, making it an environmentally friendly and cost-effective process. This has led to the development of small-scale mushroom farming industries in many developing countries, creating employment opportunities and promoting rural development. Additionally, research into the medicinal properties of *Volvariella* species has revealed potential health benefits, including antioxidant and immune modulatory effects, further enhancing their value in both traditional and modern healthcare systems. Mushroom cultivation is a short return agricultural business and can be of immediate benefit to the community. The edible straw mushroom, *Volvariella volvaceae* (Bull.) Singer. is a fungus of the tropics and subtropics and has been cultivated for many years in China (Benemerito, 1974), and in other Asian countries. Khan et al. (1981) demonstrated that mushrooms provide an excellent source of protein and a rich dietary supply of minerals and vitamins. According to Tewari in 1986, mushrooms are mostly water at 85 to 95 percent with protein at 3 percent, carbohydrates at 4 percent, fats at 0.1 percent and minerals and vitamins at 1 percent. Mushrooms deliver healthy amounts of potassium, phosphorous, copper and iron but keep calcium levels low. (Anderson and Feller, 1942). The protein content of mushrooms sits between what we find in animals and vegetables. (Kurtzman, 1976). Research by Subramanian (1986) shows that mushroom contains substantial quantities of Niacin, pantothenic acid and biotin. Sahoo's (1999) research shows that India operates two commercial *Vovariell*a species known as *Volvariella volvaceae* and *Volvariella diplasia.* The present study aimed to evaluate the bioefficiency and bioconversion of two species of *Volvariella* {*Volvariella volvaceae* (Bull.)Singer and *Volvariella diplasia* (Berk. & Broome) Singer**}** grown on rice straw as the substrate .

2. Material and methods

2.1. Preparation of Mushroom beds of *Volvariella* spp

Tall variety of rice straw (*Oryza sativa var*. CR 30; *O.sativa var*. jajati, *O.sativa* var. pathara etc.) was used for preparation of bed. We used rice straw bundles of 2 feet long and 10 cm thick to build our bed.. The rice straw bundles were soaked in water for 15 to 16 hours and then removed from water and were kept in inclined position to remove excess water. The soaked straw bundles were boiled for 30 minutes, removed the excess water and was placed length wise very close to one another on the bamboo bed platform. About 20 to 25 bundles were used for preparation of a single bed. The water-soaked straw bundles were arranged evenly across four successive layers of the container. The experiments on *Vovariella* were conducted from April to September.

2.2. Construction of bed platform

The bed platforms were prepared inside "mushroom house" made up of bamboo for cultivation of mushroom. The bamboo sticks were made a rectangular shaped tires in the mushroom house. The 1st tire or platform of the bed was made 2feets above the ground to avoid dirty, insects as well as contamination of soil microorganisms. The experiments were not done simultaneously in a single bed.

The 1st layer of straw bundles was constructed on the bamboo bed platform by placing 5 to 6 bundles very close to each other on East-West direction. The 2nd layer was placed on the 1st layer of the bundles. The bundles were kept on opposite direction of the 1st layer i.e. on North-South direction. The 2nd layer was totally cover on the 1st layer. Similarly, the 3rd layer was constructed over the 2nd layer in East-West direction i.e like to 1st layer. The 4th or top most layer was placed over the 3rd layer in similar way to the 2nd layer. The first, second and third layer were 6 inches in thickness and were made of 5 to 6 bundles, but the forth layer was 2 to 3 inches in thick and made up of 2 to 3 bundles of the straw.

After the rice straw bed had been prepared, it was sized by cutting the straw which were out of the bed. The bed was pressed gently to remove the air gaps among the layers in the bed to make appropriate compactness for the mycelial run as well as to check contamination. Therefore, the volume of the bed become length 25", Width 25" and height 20".

2.3. Spawning the bed

One bottle of spawn (approximately 350 g) was used to spawn each bed. The spawn bottles were broken or dug using a glass rod and the spawn ball was kept in a container. They were then made into small bits, each containing three to five grains before spawning. The spawning was made along with gram powder. Two hundred and fifty grams of gram powder was used for the preparation of a single bed. Spawning was performed on each bed layer. The 1st and 2nd layers were spawned with spawn bits about 2 to 3 inches apart from the edge, where no spawning was done in the middle space.

2.4. Maintenance of bed

The cultured room was maintained 30^0 to 35^0 C during fructification. The entire bed was covered with polythene to maintain appropriate humidity. A water sprayer did watering at regular interval of two days.

2.5. Fruiting

The pinheads of *Volvariella* were emerged out after 5 to 6 days after spawning. The mushrooms were ready for harvest after 3 to 4 days (9 to 10 days after spawning). During harvesting, the polythene cover was removed gently, and plucking was performed by hand carefully without disturbing the adjacent pinheads. The polythene was then covered for the next flush. The 2^{nd} and 3^{rd} flush were harvested with a week gap i.e. 2^{nd} crop was harvested one week after the 1^{st} crop and 3^{rd} crop was harvested one week after the second crop, and watering was continued until the last crop was harvested. The fresh weight of the mushrooms was measured using a digital balance; then, they were placed immediately in an oven at 80^0C for 48 h, and the dry weight was recorded. Measurements of protein, carbohydrate, and nucleic acid contents in mushrooms were estimated according to the methods of Lowary *et al.. al.*, 1951; Morris, 1948; Mallik and Singh, 1980.

The following parameters were computed basing on following formula: -

Biological efficiency (BE) = Fresh weight of mushroom / Air dry weight of substrate × 100

Production rate (PR) = Biological Efficiency (%) / time (days)

Compost net loss = Compost dry weight. – (Compost dry weight after cultivation + mushroom dry weight)

Dry material loss rate = Net weight loss of dry material /total dry weight of original substrate × 100

Bioconversion rate = Dry weight of the fruiting body / Dry material net loss × 100

3. Results and discussion

The bioefficiencies of *V. volvacea* and *V. diplasia* are shown in Table 1. The bioefficiencies of *V. volvacea*e was 56.73% and *V. diplasia* was 55.83%. The dry weights of the compost was 980.45 and 985.34 gm, and mushroom fruiting body wt. was 556*.23 gm and 550.15 gm mushroom.* The production rate was 4.72 *in V. volvaceae and* 4.65 *in V .diplasia*.The bioconversion of dry compost into fruiting bodies in *Volvariella* grown on rice straw is presented in Table 2. The dry wt. of the compost after cultivation of *V. volvaceae* and *V. diplasia* were 551.24 gm and 535.16 gm respectively. The fruit body conversion rate (%) were 8.09 in *V. volvaceae* and 7.20 in *V. diplasia*. The biochemical contents such as carbohydrate, protein and nucleic acid were 32.26, 43.28 & 3.0 % dry weight respectively in *V. volvaceae* and these values are 33.21, 42.83 and 2.9 % of dry weight respectively in *V. diplasia*. "Biomass conversion efficiency" is dependent on the occurrence of contaminants and growth competitors in the growth substrate during mushroom cultivation (Rajarathnam et. al., 1987 and Gandy, 1985). Biomass includes the mycelium generated in the growth substrate, developed fruiting bodies, and mycelium grown in liquid culture. Rajarathnam (1981) identified several enzymes responsible for the degradation of the growth substrate of mushroom mycelia. The bioefficiencies of *Volvariella volvacea* and *Volvariella diplasia* were 56.73% and 55.83 % respectively. The bioefficiencies observed in this study align with previous findings reported by Zardarazil (1978) and Mehera (2001). The production rates and fruit body conversion rates for both *V. volvaceae* and *V. diplasia* indicate their potential for efficient mushroom cultivation. These results suggest that optimizing substrate combinations and environmental conditions, as noted by Patro and Pani (1995), could further enhance the bioconversion rates of these *Volvariella* species.This study provides valuable insights into the cultivation efficiency of these mushroom species and offers a foundation for future studies aimed at improving their production and yield.

Table 1 Bioefficiency of *Volvariella* grown on rice straw as substrate. Each value is mean of 10 replicates± SEM

Species	**Days after harvested**	**Compost dry wt. (g)**	**Mushroom fruit body freshwt. (g)**	**Mushroom fruit body dry wt. (g)**	**Bio efficiency (%)**	**Dry mushroom yield rate (%)**	**Production rate**
V.*volvaceae*	12	980.45±10.15	556.23±19.34	32.16±3.52	56.73	3.68	4.72
V .diplasia	12	985.34±15.12	550.15±10.12	30.24±4.48	55.83	3.31	4.65

Table 2 Bioconversion of dry compost into fruit body in *Volvariella* grown on rice straw substrate with their carbohydrates, protein and nucleic acid content. Each value is mean of 10 replicates ± SEM

Species	Compost dry wt.(g) after cultivation	Compost net loss (g)	Fruit body conversion rate (%)	Compost loss rate (%)	Carbohydrates content (% dry wt.)	Protein content (% dry wt)	Nucleic acid content (% dry wt.)
V.*volvaceae*	551.24±11.32	397.05±9.56	8.09	40.49	32.26	43.28	3.0
V.diplasia	535.16±10.25	419.94±9.28	7.20	42.61	33.21	42.83	2.9

4. Conclusion

This study highlights the significant potential of *Volvariella* mushrooms in converting rice straw into a high-quality protein source, offering solutions to both nutritional challenges and environmental concerns. The findings demonstrate that *Volvariella volvacea* and*Volvariella diplasia* show comparable bioefficiencies, with slight variations in their biochemical makeup and ability to convert biomass. Future research could explore optimizing cultivation conditions and experimenting with different agricultural byproducts to enhance the effectiveness and sustainability of mushroom-based bioconversion techniques.

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