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Studies on *Volvariella esculenta* (Mass) Singer: cultivation on agricultural wastes and proximate composition of stored mushrooms

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Volvariella esculenta (Mass) Singer, a Nigerian edible mushroom, is able to grow at a temperature range of 20–40°C (optimum = 35°C) and pH range of 3–10 (optimum = 6.0). It is able to utilize a wide range of agricultural wastes for vegetative growth and fructification. Of these the rice straw induced the widest mycelial extension while rice bran produced the highest mycelial density. Similarly, the unfermented cotton waste compost produced the highest fruitbody yield. Post-harvest storage at 12°C for 1 day preserved the texture and nutrient composition of fresh mushrooms whereas extension of storage time did not prevent deterioration. These results are discussed in relation to cultivating *V. esculenta* as a commercial mushroom in Nigeria.

INTRODUCTION

Volvariella esculenta is one of the two highest-priced Nigerian edible mushrooms (Zoberi, 1972) because of its meaty taste, desirable flavour and medicinal value. It is popular especially among local farmers who fondly refer to it as the 'farmers' seasoning' (Oso, 1975). Farmers have perfected a method of cultivating this fungus. They usually leave fresh logs of oil-palm trees or stacks of oil-palm pericarp wastes to chance infection by spores. They are often rewarded with fruit bodies, of *V. esculenta* among others.

Volvariella esculenta is rich in proteins and minerals (Fasidi and Kadiri, 1993). Since mushroom farms are rare in Nigeria and cellulosic wastes are abundant, an attempt was made in this study to cultivate *V. esculenta*. Proximate composition of harvested stored mushrooms was also investigated to determine the best time for storing *V. esculenta* fruitbodies (at 12°C) which undergo rapid post-harvest deterioration.

MATERIALS AND METHODS

The inoculum used in this study was obtained by tissue culture of *V. esculenta* sporophores collected from Apoje Oil Mills Limited, Apoje, Nigeria, and established on potato dextrose agar medium (PDA).

Temperature and pH requirements

The temperature requirement of *V. esculenta* was investigated on PDA. The medium (comprising extract from 200 g of Irish potato, 20 g agar and distilled water, 1 litre) was sterilized in an autoclave at 15 p.s.i. (121°C) for 15 min. Streptomycin sulphate (0.1 g) was added to the medium after it had cooled to about 40°C before being poured into Petri dishes. The dishes were inoculated with a 10 mm (diameter) disc of 4-day old *V. esculenta* mycelium and incubated at 15, 20, 30, 35 and 40°C. Each treatment was replicated three times. After 4 days, the mycelial diameter was measured while mycelial density was compared visually.

The pH requirement was determined by a mycelial-dry weight method, using a liquid medium (Alofe, 1985). The liquid medium was dispensed in 30 ml lots into 250 ml milk bottles, adjusted to pH values (3–10) and autoclaved for 15 min at 15 p.s.i. Each medium was inoculated with a 10 mm (diameter) mycelium and incubated at 30 ± 2°C. Each treatment was thrice replicated.

Vegetative growth on agricultural wastes

Growth on wastes was evaluated according to the method used by Fasidi & Kadiri (1993). Each waste (10 g) was soaked in hot water (80°C), pressed to remove excess water and put into 10 cm (diameter) Petri dishes. Dishes were sterilized at 121°C for 15 min, inoculated and incubated for 5 days at 30 ± 2°C. Each treatment was thrice replicated.

Cultivation of fruitbodies

Four kilogrammes each of dry cotton waste, corn cob, cassava peels, rice straw and sawdust were used. Corn cob and cassava peels were chopped into 1–3 cm pieces

while rice straw was tied in 1 kg bundles. Cotton waste, corn cob, cassava peels and sawdust were soaked in water and pressed to expel excess water until the moisture content was about 60%. Rice straw bundles were soaked in water for 3 h and air-dried to expel excess water. Cotton waste was teased into small pieces. The processed wastes except rice straw were each mixed with 10% rice bran (w/w). These wastes and rice straw bundles were packed separately in sacks and steamed (100°C) for 4 h in drums. Steamed rice bran was mixed with the rice straw bundles after steam sterilization. Each treatment was replicated 3 times. The sterilized wastes were arranged in flat heaps on a clean terrazo floor in a cropping room at 27±2°C and 87.2% R.H. and each was inoculated with 400 g cotton waste spawn.

Cotton waste spawn was prepared by the method described by Fasidi & Ekuere (1993). Each spawned compost was covered with a clean transparent polyethylene sheet. After 11 days the polyethylene sheets were removed to aerate the compost and water as necessary to initiate fruitbodies.

Table 1. Effect of temperature on mycelial extension and density of *V. esculenta*

Temperature (°C)	Mycelial extension (cm)	Mycelial density
15	–	–
20	0.6±0.1	+
30	6.1±0.1	3+
35	8.5±0.7	5+
40	5.3	2+

Table 2. Effect of pH on mycelial dry weight of *V. esculenta*

pH value	Dry weight of mycelia (mg)
3.0	20.0
4.0	126.7±49.4
5.0	120.0±20.0
6.0	176.7±6.0
7.0	126.7±21
8.0	156.7±15.3
9.0	160.0±26.5
10.0	150.0±30.0

Proximate composition of stored mushrooms

Fruitbodies were harvested from the cotton waste compost at the 'egg' stage and stored in a perforated polyethylene bag in the refrigerator at 12°C. For analysis, fruitbodies were dried at 55°C for 4 days and powdered.

Ethanol-soluble sugar was extracted in boiling 80% ethanol for 4 h and quantified colorimetrically (Dubois *et al.*, 1956). Glycogen was determined by hydrolysing ethanol-insoluble residue with 1% H_2SO_4 and quantified by the anthrone reagent method (Hassid & Neufield, 1964; Southgate, 1969). Total nitrogen was determined by the Kjeldahl method. Crude protein was obtained by multiplying the total nitrogen by 6.25 (Bishop, 1928). Free amino-nitrogen was extracted in water and quantified by the titration method of Richardson (1934). Lipid was extracted in chloroform.

RESULTS AND DISCUSSION

The optimum temperature and pH obtained for the growth of *V. esculenta* mycelium were 35°C and 6.0, respectively (Tables 1 and 2). Temperature and pH are important environmental factors that control the growth of fungi (Bisby, 1943). In this study, *V. esculenta* was able to tolerate temperature and pH ranges of 20–40°C and 3–10, respectively. This ability probably enables it to flourish on wastes in the tropics. Chang & Chu (1969) reported 30–35°C as the optimum range for *V. volvacea* mycelial growth with 32°C as the most suitable temperature.

Volvariella esculenta mycelia grew fairly well on a wide range of cellulosic wastes (Table 3). Rice straw supported the fastest mycelial extension followed, in order, by cotton waste, *Pennisetum polystachion* straw and cassava peels; yam peels supported the poorest mycelial growth. This result is similar to that reported by Fasidi & Ekuere (1993) for *Pleurotus tuber-regium*. Rice straw is the natural substrate on which *V. esculenta* grows; hence it is called 'the delicious straw mushroom' (Hashioka, 1962). Rice straw, cotton waste, corn cob and sawdust are common substrates for the cultivation of edible mushrooms world-wide (Chang & Fernandez,

Table 3. Mycelial growth and fructification of *V. esculenta* on agricultural wastes

Wastes	Mycelial extension (cm)	Mycelial density	Fruitbody yield (g/kg waste)	Biological efficiency (%)
Sorghum chaff	5.5±1.0	8+	–	–
Corn chaff	7.0±0.5	8+	–	–
Yam peel	2.0±0.3	6+	–	–
Cassava peel*	8.4±0.2	6+	21	2.1
Rice bran	4.8±1.3	9+	–	–
Corn cob*	8.7±0.1	4+	0	0
Rice straw*	9.0±0.3	5+	63.0	6.3
Cotton waste*	8.9	7+	89.0	8.9
Pennisetum polystachion straw	8.8	3+	–	–
Sawdust*	4.3±0.2	3+	0	0

*For cultivation, 10% rice bran was added.
–Not determined.

Table 4. Proximate composition of mushrooms stored at 12°C for 3 days (data are calculated as % dry weight)

Period of storage (days)	Protein	Amino acids	Ethanol-soluble sugars	Glycogen	Lipid
0	41.8	3.6	2.0	35.0	3.0
1	43.9	2.7	2.1	37.5	3.0
2	53.3	2.6	1.7	21.3	7.4
3	35.2	2.3	1.7	30.0	4.0

1980; Chang, 1982). Rice bran supported the highest mycelial density (Table 3). This is not surprising because rice bran is rich in oils and vitamins (Bolton & Blair, 1982) which stimulate mushroom yield (Schisler & Sinden, 1966).

Cotton waste, cassava peels and rice straw supported the fructification of *V. esculenta* but sawdust and corn cob did not (Table 3). Fructification was first initiated 13 days after spawning on cotton waste and rice straw and the former produced the highest yield of the wastes investigated. Chang (1983) reported that cotton waste gave a higher and more stable yield than other agricultural wastes. The higher yield produced on cotton waste is due to its higher proportion of cellulose and compactness on wetting (Chang, 1983). The inability of *V. esculenta* to fructify on corn cob and sawdust may be due to their looseness and poor nutrients.

Refrigeration (at 12°C) for 1 day preserved the ('egg') fruitbodies of *V. esculenta* physically. Moreover, there was no meaningful difference in the nutrient composition of fresh mushrooms and those refrigerated for 1 day (Table 4). In contrast, mushrooms refrigerated for 2–3 days showed signs of spoilage (discoloration and stickiness) and much variation in nutrient composition. Crude protein and lipid increased until the second day and decreased thereafter, whereas sugars and amino acids decreased gradually. Glycogen did not show a definite pattern. It is therefore clear from these results that *V. esculenta* ('egg') fruitbodies refrigerated for 1 day are good nutritionally and commercially. Further refrigeration did not arrest deterioration of fruitbodies or fluctuation of nutrient composition.

In conclusion, cultivation of *V. esculenta* has great potential for commercial venture in Nigeria because agricultural wastes are abundant and Nigerians accept mushrooms as food. However, the yield obtained on wastes in the present study was low. Upgrading of yield will therefore be considered as the next objective.

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