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Full Length Research Paper

Effect of *Volvariella volvacea* cultivaton on the chemical composition of agrowastes

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The Mushroom, *Volvariella volvacea*, was cultivated on various agrowastes. Maximum mycelia extensions were recorded in cotton waste (98.23 ± 0.1 mm) and a combination of rice husk and cotton waste (101.87 ± 0.4 mm). A decrease in moisture content resulted in significant increase percentage crude protein content of mushroom-treated waste compared to the untreated. Moisture content decreased from 61.48 in the mushroom-treated groundnut shell to 51.20% in the untreated. Untreated Groundnut shell had crude protein of 3.61% while treated had 8.42%. Crude protein content of sorghum shaft increased from 2.51% in the untreated to 8.77% in treated waste. Similar trend was observed in the various waste combinations. While changes in crude fibre and ash content of treated and untreated wastes were not significant, mineral contents were observed to increase. Phosphorus and potassium ion content also increased in mushroom-treated samples.

Key words: *Volvariella volvacea*, agrowastes, chemical composition.

INTRODUCTION

Volvariella volvacea, the fourth most important cultivated edible mushroom in the world (Chang, 1983), known as 'Ogiri-agbe' among the Yoruba's of Nigeria, is a popular edible fungus of the tropics and subtropics which grows well on cellulosic agricultural residues and industrial wastes (Chang, 1978; Chang and Yau, 1971).

Large quantities of agricultural wastes (agrowastes) are generated all over the world. The environmental pollution problems associated with conventional disposal methods in Nigeria (Belewu and Banjo, 2000) necessitate the search for alternative, environmentally friendly methods of handling agrowastes. Mushrooms have been reported to be capable of transforming nutritionally worthless wastes into protein rich food and have been confirmed to be sources of single cell protein (Kurtzmam, 1981; Alofe et al., 1998). The cultivation of edible mushroom like *V. volvacea* on these wastes may thus be a value added process capable of converting these materials, which are otherwise considered to be wastes, into foods and feeds (Bisaria et al., 1997). The cultivation of *V. volvacea* on agrowastes may also offer economic incentives for agribusinesses to examine these residues as valuable resources and develop new enterprises by using them to produce nutritious mushroom products (Bisaria et al., 1987). In the humid tropics, pieces of land are cultivated continuously, leading to loss of soil fertility, nutrient deficiency symptoms on the crop and loss of yield. High cost and scarcity does not encourage the use of fertilisers, hence the need to the use of locally and readily available plant residues which are usually discarded.

The objective of this work was to study the effect of *V. volvacea* cultivation on the chemical composition of agricultural wastes, namely: rice husk (RH), rice straw (RS), cotton waste (CW), groundnut shell (GS), cassava peel (CP), corn cob (CC), white afra dust (WAD), red afra dust (RAD) and oil palm pericarp (OPP) and red sorghum shaft (RSS) singly and in combination, and evaluate the potentials of these agrowastes for use in food and or feed formulation.

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Table 1. Proximate composition (%) of agricultural waste before and after treatment with *Volvariella volvacea* mycelia.

Waste	Treatment	Protein	Fat	Ash	Carbohydrate	Fibre	Moisture content
GS	T	8.42^{h}	6.41^{g}	7.84^{d}	3.52^{b}	22.61^{kl}	51.20^{a}
	U	3.61^{b}	1.41^{a}	7.78^{d}	3.39^{b}	22.33^{k}	61.48^{c}
OPP	T	2.08^{cb}	5.78^{f}	4.55^{e}	3.10^{b}	8.99^{e}	75.50^{h}
	U	2.67^{u}	1.85^{a}	5.94^{c}	16.16^{i}	9.39^{f}	63.99^{cd}
CP	T	5.71^{f}	6.06^{g}	8.16^{f}	3.48^{a}	18.91^{j}	57.68^{b}
	U	4.73^{e}	0.19^{b}	14.78^{k}	15.14^{h}	11.68^{g}	53.48a
SS	T	8.77^{i}	7.70^{h}	10.89^{h}	2.62^{a}	9.73^{f}	60.29^{c}
	U	2.51^{c}	0.23^{b}	3.57^{a}	10.00^{f}	18.09^{j}	65.30^{d}
CW	T	4.65^{e}	4.03^{d}	13.04^{j}	4.10^{c}	21.84^{f}	52.34^{a}
	U	2.15^{fc}	4.78^{e}	8.59^{f}	5.70^{d}	23.77^{l}	55.01^{b}
RS	T	4.74^{e}	3.08^{c}	12.01^{i}	4.48^{c}	18.92^{j}	56.77^{b}
	U	10.47^{j}	1.49^{a}	8.64^{f}	6.65^{e}	7.32^{c}	65.43^{d}
RAD	T	6.20^{g}	3.10^{c}	8.40^{f}	5.98^{d}	8.04^{d}	68.28^{ef}
	U	1.33^{a}	0.31^{b}	3.98^{a}	12.71^{g}	12.47^{h}	69.20^{gf}
WAD	T	1.71^{b}	5.08^{e}	5.89^{c}	3.74^{b}	11.66^{g}	71.92^{g}
	U	1.23^{a}	1.77^{a}	5.28^{b}	3.46^{b}	3.67^{a}	74.59^{h}
CC	T	1.16^{a}	4.18^{d}	9.33^{h}	3.76^{b}	24.09^{m}	57.48^{b}
	U	3.86^{d}	1.26^{a}	8.54^{f}	12.51^{g}	16.52^{i}	55.62^{b}
RH	T	11.86^{k}	7.33^{h}	5.00^{b}	5.08^{d}	5.76^{b}	54.97^{a}
	U	3.48^{d}	1.32^{a}	5.22^{a}	6.72^{e}	10.84^{g}	67.48^{e}

U, Untreated waste; T, Treated waste; GS = Ground nutshell; OPP = Oil Palm Pericarp; CP = Cassava Peel; SS = Sorghum Shaft; CW = Cotton Waste; RS = Rice Shaft,RAD = Red Afra Dust; WAD = White Afra Dust; CC = Corn Cob; RH = Rice Husk;

MATERIALS AND METHODS

Collection, identification and isolation of *V. volvacea* mycelium

Fruiting bodies of *V. volvacea* were harvested from the heap of discarded oil palm pericarp waste at the oil palm mill, the Federal College of Agriculture, Akure, Ondo State, Nigeria. Initial identification of mushroom was carried out as described by Alofe et al. (1996), Oso (1975) and Zoberi (1972). The mycelium of *V. volvacea* was isolated and obtained by tissue culture from the pileus of a young sporophore. These pieces of tissue were placed aseptically on sterilized Potato dextrose agar (PDA) and mycelium was allowed to germinate and develop from the spores. The developed mycelium was maintained on PDA by regular sub culturing (every two weeks) throughout the period of investigation.

Preparation of growth medium and growth of *Volvariella volvacea*

The following unfermented agricultural wastes, namely: Rice husk (RH), Rice shaft (RS), Cotton waste (CW), groundnut shell (GS), cassava peel (CP), corn cob (CC), white afra dust (WAD), red afra dust (RAD), oil palm pericarp (OPP), red sorghum shaft (RSS) and their blends (1:1 w/w), namely: RH-RAD, OPP-GS, CC-GS, CP-SS, CW-RH, and OPP-CP were chopped (where necessary), soaked in hot water (80°C, 30 min), and then pressed to expel excess water till the moisture content was about 60%. 10 g of rice bran and 4.0 g of $CaSO_4$ were added to 56.0 g of each waste and mixed together properly in a container. 10 g of each mixture was then transferred into a clean petri dish, sterilized (121°C, 30 min), cooled, inoculated with a 72-hour old culture of mycelia using a 5 mm disc and incubated at 30±2ºC for 8 days. Uninoculated sterile plates were used as control.

Chemical analysis

The proximate and mineral composition, namely: calcium, magnesium, iron, zinc (using Pye Unicam sp 9 AAS) sodium and potassium (using flame photometer) of each agrowaste and blend was determined before and after colonization by *V. volvacea* mycelia using standard methods (AOAC, 1995).

Statistical analysis

Means of triplicate reading were determined and subjected to analysis of variance. Means were separated using Duncan's Multiple Range Test with the aid of statistical package for social scientists (SPSS version 10.0).

RESULTS

Proximate and mineral composition of treated and untreated agricultural wastes

Tables 1 and 2 show the proximate and mineral composition of various wastes and their blends before

Table 2. Proximate composition (%) of agricultural waste combinations before and after treatment with *Volvariella volvacea* mycelia.

Waste combination	Treatment	Protein	Fat	Ash	Carbohydrate	Fibre	Moisture content
RHRAD	T	6.41^{g}	3.15^{c}	8.01^{d}	7.10^{f}	3.15^{a}	66.88^{c}
	U	4.38^{c}	0.51^{a}	6.90^{c}	5.49^{d}	15.77^{h}	66.95^{c}
OPPGS	T	6.44^{g}	10.68^{f}	5.01^{a}	7.78^{g}	10.68^{f}	56.31^{a}
	U	3.14^{a}	0.79^{a}	5.36^{b}	13.90^{j}	13.95^{g}	62.80^{b}
CCGS	T	2.87^{c}	4.43^{d}	8.30^{d}	3.00^{a}	4.43^{b}	57.98^{a}
	U	2.32^{b}	3.26^{c}	5.95^{b}	10.71^{i}	16.75^{h}	61.01^{b}
CPSS	T	5.80^{f}	4.20^{d}	11.00^{e}	6.61^{e}	5.60^{c}	58.24^{a}
	U	6.36^{g}	0.71^{a}	16.02^{g}	10.43^{i}	9.69^{e}	56.99^{a}
CWRH	T	5.38^{f}	4.20^{d}	8.45^{d}	4.01^{c}	3.80^{ab}	74.16^{d}
	U	1.56^{a}	4.79^{e}	18.01^{h}	3.73^{b}	22.62^{i}	59.79^{b}
OPPCP	T	6.41^{g}	3.15^{c}	8.43^{d}	6.99^{fe}	8.01^{d}	67.01^{c}
	U	3.51^{g}	2.65^{b}	12.63^{f}	8.58^{h}	13.54^{g}	60.82^{b}

RHRAD = Rice Husk Red Afra Dust;
OPPGS = Oil Palm Pericarp + Groundnut Shell
CCGG = Corn Cob + Groundnut Shell
CPSS = Cassava Peel + Sorghum Shaft
CWRH = Cotton Waste + Rice Husk
OPPCP = Oil Palm Pericarp + Cassava Peel

and after the growth of *V. volvacea.* Results show significant increases in the protein and fat contents of the wastes following the growth of *V. volvacea*. The percentage protein content of agricultural wastes treated with mushroom mycelia increased significantly when compared with the untreated samples (Table 2). Untreated groundnut shell had a protein content of 3.61%, while the treated sample had 8.42%, protein content of sorghum shaft increased from 2.51% in the untreated sample to 8.77% in the treated sample, while that of rice husk increased from 3.48 to 11.86%. The percentage fat content of the untreated samples was observed to be lower than that of the treated samples. The percentage fat content of cassava peel increased from 0.19 to 6.06% in the treated sample, corn cob from 1.26 to 4.18%, oil palm pericarp waste from 1.85 to 5.78%, red afra dust from 0.31 to 3.10% and that of white afra dust from 1.77 to 5.08% (Table 2). There were no significant difference in the carbohydrate, ash, moisture and fibre content of the treated and untreated samples though a general decrease was observed.

The percentage protein content of combinations of agricultural wastes treated with mushroom mycelia also increased significantly when compared with the untreated samples (Table 3). Combination of untreated rice husk and red afra dust had a protein content of 6.41%, while the treated sample had 4.38%, protein content of combination of oil palm pericarp and groundnut shell increased from 3.14% in the untreated sample to 6.44% in the treated sample, while that of cotton and rice husk increased from 1.56% to 5.38% . The percentage fat content of combination of the untreated samples was observed to be lower than that of the treated samples. The percentage fat content of cassava peel and sorghum shaft increased from 0.71 to 4.20 % in the treated sample, oil palm pericarp waste and groundnut shell from 0.79 to 10.68%, red afra dust and rice husk from 0.51 to 3.15% (Table 3). There were no significant differences in the carbohydrate, ash, moisture and fibre content of the treated and untreated samples though a general decrease was observed.

The mineral compositions of treated and untreated agricultural wastes are shown in Table 4. Phosphorus content of treated samples was higher than that of their untreated counterpart. The phosphorus content of untreated rice husk was 0.42 mg/kg, while that of treated was 1.48 mg/kg. Untreated cassava peel had phosphorus content of 0.81 mg/kg while the treated had 2.92 mg/kg, untreated cotton waste had 0.25 mg/kg while treated had 3.75 mg/kg (Table 4). The calcium content of untreated wastes was higher than the treated samples. Untreated groundnut shell had 9681 mg/kg, and the treated had 1290 mg/kg; untreated rice husk 9600 mg/kg and the treated had 1930 mg/kg.

The mineral composition of treated and untreated agricultural wastes were shown in Table 4. Combination

Table 3. Mineral composition of agricultural wastes before and after treatment with *Volvariella volvacea* mycelia.

Waste	Treatments	P	K	Na	Ca	Mg
GS	T	3.16^{fg}	0.52^{a}	1.84^{e}	1290^{bc}	6261^{h}
	U	1.12^{d}	1.20^{d}	5.60^{i}	9681^{p}	3360^{d}
OPP	T	4.17^{i}	2.04f	1.20^{d}	1870^{f}	7400^{j}
	U	1.66^{de}	1.28^{d}	3.20^{h}	4800^{l}	1441^{b}
CP	T	2.92^{f}	1.48^{d}	1.04^{cd}	1160`^{a}	3364^{d}
	U	0.81^{c}	1.04^{c}	2.81^{g}	3200^{i}	2880^{c}
SS	T	1.47^{d}	1.72^{e}	1.08^{d}	1260^{b}	3842^{e}
	U	1.33^{d}	1.08^{c}	3.00^{gh}	8800^{n}	1440^{b}
CW	T	3.75^{h}	0.80^{b}	1.66^{e}	1320^{cd}	3726^{e}
	U	0.25^{a}	0.42^{a}	2.94^{g}	14400^{q}	4320^{f}
RS	T	1.48^{d}	5.52^{i}	1.28^{d}	1930^{f}	3891^{e}
	U	0.42^{b}	2.05^{f}	3.10^{h}	9600^{o}	3840^{e}
RAD	T	1.72^{e}	2.68^{h}	1.20^{d}	1580^{e}	4130^{f}
	U	1.50^{d}	1.41^{d}	3.20^{h}	11200^{r}	1440^{b}
WAD	T	1.35^{d}	2.64^{g}	0.96^{c}	1340^{d}	3524^{d}
	U	0.83^{c}	1.84^{e}	0.24^{a}	5600^{m}	4800^{g}
CC	T	1.26^{d}	0.72^{b}	2.16^{f}	2600^{h}	6720^{i}
	U	0.50^{b}	0.96^{c}	0.81^{c}	3894^{j}	6200^{h}
RH	T	3.24^{g}	2.61^{g}	0.24^{a}	2330^{g}	4500^{f}
	U	0.25^{a}	0.85^{a}	0.40^{b}	4226^{k}	980^{a}

U = Untreated waste; T = Treated waste; GS = Ground nutshell; OPP = Oil Palm Pericarp
CP = Cassava Peel; SS = Sorghum Shaft; CW = Cotton Waste; RS = Rice Shaft
RAD = Red Afra Dust; WAD = White Afra Dust; CC = Corn Cob; RH = Rice Husk

Table 4. Mineral composition of agricultural wastes combinations before and after treatment with *Volvariella volvacea* mycelia.

Waste combinations	Treatments	P	K	Na	Ca	Mg
RHRAD	T	4.08^{bc}	3.36^{f}	0.40^{b}	2070^{c}	7150^{i}
	U	2.51^{a}	1.84^{c}	0.25^{a}	4891^{e}	5621^{f}
OPPGS	T	7.62^{f}	3.52f	2.00^{g}	2540^{d}	7200^{i}
	U	7.50^{f}	2.16^{d}	1.84^{f}	4800^{e}	6245^{g}
CCGS	T	6.04^{d}	5.45^{h}	0.52^{c}	1910^{cb}	6102^{g}
	U	3.94^{b}	2.68^{e}	0.17^{a}	5621^{f}	3850^{b}
CPSS	T	6.28^{de}	4.01^{g}	0.84^{d}	1850^{b}	4505^{d}
	U	4.50^{c}	1.87^{c}	0.65^{c}	7246^{g}	2819^{a}
CWRH	T	7.99^{f}	3.19^{f}	1.30^{e}	1270^{a}	8952^{j}
	U	6.82^{e}	1.63^{c}	0.91^{d}	4800^{e}	4194^{c}
OPPCP	T	7.76^{f}	0.60^{b}	0.22^{a}	1154^{a}	5124^{e}
	U	7.50^{f}	0.24^{a}	0.22^{a}	7200^{g}	3754^{b}

RHRAD = Rice Husk Red Afra Dust.
OPPGS = Oil Palm Pericarp + Groundnut Shell.
CCGG = Corn Cob + Groundnut Shell.
CPSS = Cassava Peel + Sorghum Shaft.
CWRH = Cotton Waste + Rice Husk.
OPPCP = Oil Palm Pericarp + Cassava Peel.

of untreated rice husk and red afra dust had phosphorus content of 2.51 mg/kg, while the treated sample had 4.08 mg/kg. Combination of untreated corn cob and groundnut shell had phosphorus content of 3.94 mg/kg and the treated sample had 6.04 mg/kg. Combination of untreated cotton waste and rice husk had calcium ion content of 4800 mg/kg, while the treated had 1270 mg/kg. Combination of untreated oil palm pericarp waste and cassava peel had calcium content of 7200 mg/kg, while the treated had 1154 mg/kg (Table 4). The magnesium contents of treated waste were higher than that of the untreated waste. Untreated rice husk had magnesium content of 980 mg/kg while the treated had 4500 mg/kg. Treated groundnut shell had magnesium content of 6521 mg/kg, while the untreated had 3360 mg/kg (Table 4). Combination of untreated corn cob and groundnut shell had magnesium content of 3850 mg/kg, while the treated had magnesium content of 102 mg/kg. Combination of untreated cotton waste and rice husk had magnesium content of 4194 mg/kg while the treated had magnesium content of 8952 mg/kg.

DISCUSSION

The agrowastes had relatively high N, P and K contents compared with Ca and Mg which are low. It is thus expected that on decomposition N, P and K would be released to influence growth of agricultural products. The result of proximate composition of various agricultural wastes before and after treatment with mushroom mycelia showed a significant increase in the protein content of treated agricultural wastes compared to their untreated counterparts while the crude fibre content decreased. Some authors reported that, the colonization of wastes by fungi results in increase in their nutritional values (Zadrazil, 1993; Belewu and Okhawere, 1998). The increase in the protein content of the treated wastes may be due to secretion of certain extracellular enzymes which are proteineous in nature into the waste during their breakdown and its subsequent metabolism (Kadiri, 1999). Protein increase could also be as a result of hydrolysis of starch to glucose and its subsequent use by same organism as a carbon source to synthesize fungal biomass rich in protein (Bender, 1970; Hammond and Wood, 1985).

Biological treatment of agricultural wastes with fungi has been found to be more effective than physical or chemical treatment. This also helps to reduce environmental pollution and also result in increase in livestock feed (Bisaria et al., 1987; Belewu and Banjo, 1990, 2000). An increase in digestibility of wastes as well as higher growth rate has been recorded in rams fed with waste subjected to this type of treatment (Bano and Rajatham, 1989). Rice husks treated with *Trichoderma harzianum* recorded a similar increase in nutrient composition and these has been found to compensate for the low and poor protein content of concentrate diets or raw straw and hay consumed by animals in the tropical environment (Belewu, 1999; Belewu and Banjo, 2000).

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