

Nutritional qualities of corn cob and waste paper incubated with edible mushroom

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Abstract

Studies were conducted to evaluate corn cob and waste paper cultured with edible mushroom (*Pleurotus sajor*) as a means of improving their nutritive value for livestock animals. Waste paper and corn cob were 14.2 and 47.7% DM respectively. Crude fibre degradation was 25.0% for corn cob and 7.21% for waste paper which was intermediate to 34.0 and 10.30% of the untreated samples. Digestibility of the fungus treated paper and corn cob were assessed using 24 Wistar Albino rats. Dry matter digestibility of the paper and the corn cob were improved by incubating with the mushroom with an increase of 30 and 40% waste paper and corn cob respectively. The crude protein digestibility and crude fibre digestibility were improved by incubation with mushroom compared with untreated samples. It was concluded that such biodegradation and the concurrent 30.2 and 27.8 percentage unit increases in crude protein digestibility of corn cob and waste paper may in fact improve the nutritive value for livestock with no detriment to the health (organ and blood) of the animals.

Key words: Nutritional qualities, waste paper, corn cob, *Pleurotus sajor caju*.

Introduction

Attempt to improve the nutritive value of waste agricultural residue, by biological means have produced varied results (Han, *et al.*, 1975; Lynch *et al.*, 1977; Streeter *et al.*, 1982; Rolz *et al.*, 1986; Belewu, 1999; Belewu, 1999; Belewu and Afolabi, 2000; Belewu, 2001). Belewu (1999) in contrast to Han *et al.* (1975) reported that *Pleurotus sajor caju* increased the in-vitro dry matter enzymatic digestibility (IVDMED) of cotton waste and sawdust. While Lynch *et al.* (1977) reported no delignification of various crop residues incubated with fungus, *Diplodia gossypina*.

Mushrooms are classified as white rot fungi and many are known to delignify plant materials as well as being edible by man (Oso, 1975; Chang

and Hayes, 1978). Initial studies in our Laboratory showed that *Pleurotus sajor caju* grew well on cotton waste but its growth on sawdust was slow and poor (Belewu and Banjo 1999; Belewu and Afolabi, 2000 and Belewu, 2001).

No ill effects were observed among rats, West African dwarf sheep and goats fed rice husk or sorghum stover that had been incubated with fungus (*Trichoderma harzanium*) (Belewu and Okhawere, 1998; Belewu, 1999; Belewu, 2000). The in-vitro dry matter enzymatic digestibility (IVDMED) was improved in the mushroom treated rice husk by 55.8% compared with 43.2% sawdust (Belewu and Banjo, 1999). The present study was to evaluate the incubation of *Pleurotus sajor caju* with corn cob and waste

paper under tropical conditions with the aim of improving the nutritive value of the substrates for livestock animals.

Materials and Methods.

Cultures of *Pleurotus sajor caju* were obtained from inoculum (culture containing immature fungal spores) which was prepared by tissue culture technique and maintained on petri plates of potato dextrose agar (PDA). All plates were incubated at room temperature (32%).

Spawn which is the pure culture of mycellum on grains was prepared according to the method of OEI (1996). Briefly, two litres of de-ionised water was added to 200g of sorghum grain and boiled in a large pot. It was later drained while additives like CaCO_3 (20g) and gypsum (80g) ($\text{CoSO}_4 \cdot \text{H}_2\text{O}$) were added so as to stabilize the pH. The mixture was scooped into dextrose bottle and plugged the mouth with cotton wool. The filled bottles were later autoclaved at 121°C , $15\text{Kg}/\text{cm}^2$ pressure for 1 hour on two successful days. The bottles were shaken to prevent the sticking of the grains to the bottom of the bottle. After cooling, the grains were inoculated in an inoculating chamber with 10 x 10mm size from the full grown agar of the inoculum for each bottle. However, more pieces of the agar were added and later incubated at 37°C until mycelia envelopes the grains. Complete colonization took 2 weeks. The spawn was later stored until needed for the inoculation of substrates.

Preparation of the substrates

Corn cob (The cylindrical shoot or rachis on which the grains of maize grow) and waste paper (un-used newspapers, writing papers and other papers) were obtained from the Teaching and Research Farm, University of Ilorin and Department of Animal Production, respectively. The substrate was individual moistened with water and then transferred into polypropylene bags and sterilized in an autoclave (steam heating) at 121°C , $15\text{kg}/\text{cm}^2$ pressure for 15 minutes. This pasteurized the substrate and killed any fast growing moulds.

Inoculating the Substrates

After cooling the substrates were inoculated with 3% (w/w) spawn. The inoculated polypropylene bags were incubated in a well ventilated dark room at ambient temperature (32°C). After about 15 days of incubation the mycelial have enveloped the substrates. The inoculated substrates were transferred to the growing chamber with each bag opened and occasionally sprinkled with water to stimulate the development of fruiting bodies. About 30 days after inoculation, immature fruit bodies started development and grow out. Mature fruit bodies developed faster and harvested as they matured. The total productive period was 40 days from the date of inoculation until production ceased. The spent substrates were oven dried (70°C) and used in the formulation of diets (B and D) (Table 1). Non-incubated control samples (A = untreated corn cob, C = Untreated waste paper) of the substrates were used as standards for fungus treated treatments.

Incubation of corn cob and waste paper with edible mushroom

Table 1 *Composition of the experimental diets*

Ingredients	A	B	C	D
Corn cob	75.00 ^a	75.00 ^b	-	-
Waste paper	-	-	75.00 ^a	75.00 ^b
Soybeans	19.50	19.50	19.50	19.50
Vitamin-premix*	5.00	5.00	5.00	5.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Proximate Composition (%)				
Dry Matter	90.00	47.00	51.47	14.20
Crude Protein	8.77	11.83	7.24	10.27
Crude Fibre	34.00	23.00	10.30	7.21
Ether Extract	0.78	0.34	0.98	0.68

a. Untreated samples

b. Treated samples

* Containing per kg: Vit. A, 10,000 Int. Unit; Vit. D₃, 150,000 Int. Unit; Vit. E, 300 Int. Unit; Vit. K, 300g; Vit. B₂, 250g; Nicotinic acid, 800g; Calcium D-panthionate, 30g; Vit. B₆, 0.03g; Vit. B₁₂, 800mg; Mn 10,000; Fe, 5.00g; Zn, 4.50g; Iodine, 0.15g; Co, 0.02g and Selenium, 0.01

Feed intake and Digestibility coefficient

The feed intake and digestibility coefficient were evaluated with non-incubated substrates using 24 Wistar Albino rats (AV. BW = 24.45g). The animals which were replicated twice against the four treatments were separately housed in a perforated based cages with facilities for separate collection of faeces and urine.

The blood was taken from the jugular vein three times per week from each animal.

The feeding trial which lasted for about 10 days preceeded. the digestibility trial which lasted till the 13th day of the experiment. On the 14th day, 50% of the animals on diets A and C died. While the remaining animals on diets A and C and 3 each from diets B and. D were equally slaughtered for the evaluation of the organ weights.

Decomposition of substrates proximate composition and crude fibre were determined by AOAC (1985). All data were subjected to a completely randomized design model (Steel and Torrie, 1960) while treatment means were separated by Duncans (1955) multiple range test.

Results and Discussion

Dry matter decomposition (% of original sample) was higher in the fungus treated corn cob (52.2%) compared with that of waste paper (27.3%). For both substrates the dry matter content was lower than the mean dry matter obtained for rice husk (Belewu and Banjo, 1999). The dry matter digestibility of the fungus treated substrates showed an increase due to the pre-digestion of the substrates by mushroom. This was in agreement with previous studies (Belewu and. Banjo, 1999). However, dry matter digestibility of corn cob was superior ($P < 0.05$) to the other substrates. The crude protein digestibility of the treated substrates was significantly higher than untreated substrates due probably to the addition of fungal protein. The values (76.50% and 48.90%) indicate that corn cob was more nutritive than waste paper. The digestibility of crude fibre was significantly improved in all the mushroom treated samples over the untreated substrates (60 and 48%). The increase in fibre digestibility observed was due probably to the partial decomposition of the

crude fibre. This is in agreement with reports in literature (Belewu and Okhawere, 1993; Belewu and Banjo, 1999). It would appear that the fibrous components of the untreated substrates could have limited the digestibility. This trend is also true of the ether extract (Longe *et al.*, 1977; Obioha *et al.*, 1982). Perhaps, hemicellulose degradation by the fungus was also responsible for providing a condition which facilitate easy digestion by animals. The general superiority of mushroom treated corn cob diet over other diets support this view.

Organ Weights

Weight of the organs (Lungs, heart, kidney and spleen) were not statistically significant ($P > 0.05$) across treatments (Table 2). However, the weight of the liver increased slightly ($P > 0.05$) which may not be unconnected with the role of the liver in the nutrient metabolism, with more nutrient being available from the mushroom treated diets. This result agreed with the report of Jimoh (2001) who fed fungus treated diets to West African dwarf goats.

Table 2 Performance characteristics of rats fed experimental diets

Parameters	Treatments				± SEM
	A	B	C	D	
Dry matter intake (g/d)	14.00 ^a	28.00 ^c	92.00 ^a	20.00 ^b	1.30*
Digestibility (%)	30.25 ^b	70.23 ^d	10.20 ^a	50.00 ^c	2.50*
Crude protein intake (g/d)	1.23 ^b	3.31 ^d	0.87 ^a	2.05 ^b	0.45*
Digestibility (%)	46.30 ^b	76.50 ^c	20.76 ^a	48.90 ^b	2.90*
Crude fibre intake (g/d)	4.76 ^b	6.44 ^c	1.24 ^a	1.44 ^a	0.97*
Digestibility (%)	50.83 ^a	60.90 ^b	40.12 ^a	48.29 ^a	3.15*
Ether extract intake (g/d)	0.11	0.27	0.06	0.14	0.09 NS
Digestibility (%)	25.18 ^b	38.23 ^c	15.30 ^a	20.59 ^b	1.78*
Organ weights (% of Lvwt)					
Lungs	2.78	2.46	2.71	2.43	0.03 NS
Heart	1.80	1.58	1.69	1.73	0.01 "
Kidneys	2.24	2.26	2.30	2.19	0.02 "
Spleen	0.82	0.89	0.78	0.95	0.23 "
Liver	11.92	12.12	10.66	12.29	1.05 "
Blood parameters					
Ammonia-N (mg/100ml)	5.20	6.25	4.50	6.10	1.78 NS
(Plasma-Urea-N	0.14	0.13	0.14	0.15	0.08 "

Means followed by the same superscripts are not significantly different ($P > 0.05$)

Mortality

About 50% of rats on diets A and C (untreated substrates) died on the 14th day of the experiment while the remaining were slaughtered at the end of the experiment for organ evaluation. The death could be due probably to the poor protein content of these diets which could not support growth of the rats. Ogden and Chang (1965) reported that a minimum protein (10%) content is required for the poor growth of rat. This assertion agreed with

the protein content of diets B and D. The survival of these rats till the 14th day could probably be due to the utilization of reserves protein (blood, liver and muscles) (Platt *et al.*, 1964). These reserves may be used over a short term period of protein deficiency (Paguay *et al.*, 1972). The low crude protein could lead to a combined deficiency of energy and crude protein (Platt *et al.*, 1964) and this could result in the death of such animal.

Incubation of corn cob and waste paper with edible mushroom

Haematology

Blood ammonia-N value of the untreated corn cob (5.20) and waste paper (4.50) was slightly lower than the treated corn cob (6.25) and waste paper (6.10). The higher ammonia - N reported for the fungus treated diets (B and D) may be related to the improved protein content of these diets compared to the low protein content of diets A and C which are poorer for rats of such age. However, there was no significant difference ($P > 0.05$) among the diets (A,B,C and D) The plasma urea N(PUN) of the untreated samples (corn cob and waste paper) are similar ($P > 0.05$) while the PUN of the treated corn cob (0.13) was slightly lower than the treated waste paper and untreated samples. However, the non-significance difference of the ammonia nitrogen and plasma- urea nitrogen (PUN) among the diets is an indication that the treatment of both substrates (corn cob and waste paper) by mushroom has no health implication on the rats. This agreed with the reports of numerous workers (Lewis 1959; Belewu and Okhawere 1998; Belewu, 2000, Jimoh 2001) who tested the defiberization and nutrient implication of such diets on various livestock.

Conclusion

The results obtained in this study suggest that inclusion of Mushroom (*Pleurotus sajor caju*) treated corn cob and waste paper in the diets of Albino rat improved the nutrient intake and digestibility without ill effect to the organ weights nor blood parameters (Ammonia - N, PUN). It is concluded from this work that diets of growing rats can contain Mushroom treated corn cob or waste paper without any depression in performance. Further treatment of waste agricultural residues with mushroom is feasible in practical type of diets especially is a situation where saving in feed cost is vital.

References

A.O.A.C. 1985. Official Methods of Analysis. 15th ed; Association of Official Analytical Chemists. Washington, DC.

- Belewu, M.A. 1999. Conversion of sorghum stover into feed by *Trichoderma harzanium* and the feeding of resulting material to Red Sokoto goats. *Bioscience Res. Comm.* Vol. 13 No. 1
- Belewu, M.A. 1999. Treatment of Sorghum stover by application of fungus, *Trichoderma harzanium*. *Nigeria J. Pure and Applied Scie.* 14: 811 — 815
- Belewu, M.A. 2000. Changes in nitrogen fractions of some waste agricultural residues after solid state fermentation. *Biokemistri* Vol. 11 No.1
- Belewu, M.A. 2001. Effect of fungus (*Volvariella volvacea*) treated cotton waste as a replacement for cotton seed cake and meal by West African dwarf goat. *Trop. J. Animal Sci.* (In pres).
- Belewu, M.A. and Afolabi, O.J. 2000. Biochemical degradation of corn cob and Arborea sawdust by Oyster Mushroom (*Pleurotus sajor caju*). In *Proceeding of an International Conference on Biotechnology; "Commercialization and Food security" held at Sheraton Hotels and Tower, Abuja* between 24th and 27th October, 2000.
- Belewu, M.A. and Banjo, N.O. 1999. Biodelignification of rice husk and sorghum stover by edible mushroom (*Pleurotus sajor caju*). *Trop. J. Anim Sci.* Vol. 1 No. 1; 137 — 142
- Belewu, M.A. and Okhawere, O.C. 1998. Evaluation of feeding fungi treated rice husk to ram. In *Proceeding of the 25th Annual conf. and Silver Jubilee. Nig. Soci. Anim. Prod.* held between 21 and 24th March, 1998 at Gateway Hotel, Abeokuta, Ogun State.

- Chang, S.T. and Hayes, W.A.** 1978. *Biology and cultivation of edible Mushroom*. Academic Press. Inc. New York.
- Duncan, D.B.** 1955. Multiple range and multiple F-test *Biometrics* 11 : I — 42
- Han, Y.W., Lez, J.S. and Anderson, A.W.** 1975. Chemical composition and digestibility of rye grass straw. *J. Agric and Chem.* 23 : 928
- Hegsted, D.M. and Chang, Y.** 1965. Protein utilization in growing rats • Relative growth index as a Bioassay Procedure *J. Nutri.* 85 : 159—168.
- Jimoh, N.O.** 2001. The effects of graded levels of *Aspergillus* treated rice husk in the diets of West African dwarf goat on blood, carcass and organ measurement. B.Sc. project, Department of Animal Production, University of Ilorin.
- Lewis, D.** 1959. Blood urea concentration in relation to protein utilization in ruminant. *J. Agric. Sci Camb.* 48 : 438 — 446
- Long, O.G., Famojuro, E. O. and Oyenuga, V.A.** 1977. Available carbohydrate and energy value of cassava, yam and plantain peel for chicks. *E Afr. Agric. J.* 42(4) : 408 — 413
- Lynch, C.P., Smith, D.F., Jackson, F.D., Cope, R.C. and Simpson, N.E.** 1977. Fungal degradation and nutritional value of cellulosic waste. *J. Anim. Sci.* 44 : 883
- Obioha, F.C. and Alikwe, P.C.N.** 1982. Utilization of ensiled and Sundried cassava peels by growing swine. *Nutr. Rep. Internatiofl.* Vol. 26 No. 6 Pg. 961 — 972
- Oei, P.** 1996. Mushroom cultivation with special emphasis on appropriate technique for developing countries. Tool Publication.
- Oso, B.A.** 1975. Mushroom and the Yoruba people. *Mycologia* Vol. LXVII. No. 2 : 311- 319
- Paquay, R., Debaere, R. and Lousse, A.** 1972. The capacity of the mature cow to lose and recover nitrogen and the significance of protein reserves. *Br. J Nutr.* 27 : 27 — 37
- Platt, B.S., Heard, C.R.C. and Stewart, R.J.** 1964. Experimental protein-calorie deficiency pp. 445 – 521. In H.N. Munro (ed). *Mammalian protein metabolism* Vol. 2 Academic Press. New York
- Rolz, C., Deleon, R., DE Arriola, M.C. and DE Cabrera, S.** 1986. Bidelignification of Lemon grass and citronella bagasse by white rot fungi. *Applied Environ. Microbiol.* Vol. 52, No. 4:607-611
- Steel, R.D.G. and Torrie, J.A.** 1960. *Principle and Procedure of Statistics* 1st ed. Mc. Graw Hill book Co. New York.
- Streeter, C., Conway, K.E., Horn, G.W. and Mader, I.T.** 1982. Nutritional Evaluation of wheat straw incubated with edible mushroom, *Pleurotus ostreatus* *J. Anim. Sci.* Vol. 54, No. 1 Pg 183-188

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