

Enhancement of the nutritive values of some agro-industrial waste products by solid state fermentation.

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Abstract

This study was conducted to determine the effect of biodegradation on the nutrient contents of rice bran (RB), cassava residual pulp (CRP), saw dust (SD) and palm oil fibre (POF) by Penicilium sp. RB, CRP, SD and POF were subjected to solid state fermentation by Penicilium sp. for 7 days and the process was terminated by oven drying at 70°C for 24hours. The fermented samples were thoroughly mixed, dried and stored in sterile bottles for analyses. Results of proximate composition before and after biodegradation revealed that percentage improvement in crude protein, ether extract, ash, and gross energy were significantly (P<0.05) higher in CRP compared to RB, SD and POF. Similarly, percentage reduction in crude fibre after biodegradation was highest (P<0.05) in CRP compared to other agro industrial wastes products. It was evident that solid state fermentation using Penicillium sp enhanced the crude protein value and reduced the crude fibre contents of rice bran, cassava residual pulp, saw dust and palm oil fibre thereby increasing nutrient availability and their utilization as feed alternative ingredients for farm animal nutrition.

Key Words: Agro-industrial wastes, nutritive values, solid state fermentation

Introduction

The Nigerian livestock feed industry competes with other sectors for the consumption of conventional energy feed resources such as maize, wheat and sorghum. This competition often pushes the prices of finished feeds upwards beyond the reach of livestock farmers, thus the search for alternative, cheap, non conventional and underutilized feed ingredients such as agro-industrial by-products and wastes has become important. Agro-industrial waste products are in abundance in Nigeria and industries producing these by - products often incurred expenses for their proper disposal. The high proportion of these unutilized wastes constitute environmental (air and water) and health hazards (Iyayi, 2004, Tarhazadesh, 2010). Those that are utilized do not have their full potentials harnessed due to high fibre content, low digestibility, anti-nutrient substances, lignin and lack of knowledge and awareness of processing methods. It is therefore imperative to enhance the nutritive value of these by products through biodegradation of their non-starch polysaccharides (NSP). The advent of biotechnology, specifically fungal biotechnology, with its inexpensive mode of application, had been used as a tool for the effective conversion of these wastes into useful products (Iyayi and Aderolu, 2004). The bioconversion of agro-industrial waste products to chemical feedstock has led to extensive studies on cellulolytic enzymes produced by fungi and bacteria. It has been documented (Iyayi and Lossei, 2001) that fungi can increase the protein and soluble sugars and reduce the complex carbohydrate of agro-industrial waste products. Solid state fermentation is a unique process with great potential for recycling some of these abundant agro-industrial by- products into useful animal feed in developing countries. The process does not require the use of chemicals and is easy to manage on farm conditions or on an industrial scale (Dei *et al.,* 2008). The desirable characteristics of the fermented products include their acceptability by birds (Nagra *et al.,* 1998) and nutrient availability (Hong *et al;* 2004). This study investigated the effect of solid state fermentation on the nutritive value of rice bran (RB), cassava residual pulp (CRP) , saw dust (SD) and palm oil fibre (POF) by *Penicilium spp.*

Materials and Methods

This study was carried out in the Microbiology and Animal Science Laboratories of Ambrose Alli University (AAU) , Ekpoma, Nigeria. The agro-industrial waste products viz rice bran (RB), cassava residual pulp (CRP), saw dust (SD) and palm oil fibre (POF) were obtained from their respective milling industries in Ekpoma, Edo State, Nigeria.

Solid – State Fermentation (SSF) cultivation

The *Penicilium spp.* used for the study was obtained from the microbes' bank of Microbiology Department, Ambrose Alli University, Ekpoma, Edo State, Nigeria. The *Penicillium spp* was inoculated on potato dextrose agar (PDA) slants, sub-cultured and stored at 40°C. The inoculums were prepared by growing 25 ± 2°C for 15 days. The conidia from newly raised slant cultures were dispersed in 0.1% (w/v) solution of tween 80 by scraping it with a sterile inoculums loop under strict aseptic condition. The concentration was adjusted to 5.3 x 10^6 cfu/ml suspension and used as initial inoculums as described by Surest *et al* (2011). The fungal cultures were grown on a PDA slants for 7 days at 30°C for sporulation. The inoculums were prepared by adding 5ml of sterile distilled water which contained 0.1% (w/v) to the agar slant and were shaken vigorously. The spore suspension was adjusted to the spore concentration of 6.0 x 10^6 spores /ml. The inoculation and solid substrate were properly mixed using sterile spatula to ensure a uniform distribution (Dara *et al.,* 2012). Thereafter, 30g of each of the agro industrial by- products (RB, CRP, SD and POF) were weighed into 250ml conical flasks in triplicates. The mouth of the flasks were clogged with cotton wool and then covered with aluminium foil. The flasks were then autoclaved at 121°C for 15 minutes, after which the substrates were inoculated with the spore concentration of 6.0 x 10^6 spores /ml. A control for each substrate was also set using the same procedure without *Penicillium spp.* inoculation. The fermentation process was terminated after 7 days by oven drying at 70°C for 24hours. The samples were thoroughly mixed, dried and stored in sterile bottles for analyses.

Chemical Analysis

The crude protein, ether extract, crude fibre, ash, moisture, gross energy compositions and fibre fractions of the unfermented and fermented samples were determined (AOAC 2000). While, nitrogen free extract was determined by subtracting the summation of other proximate fractions from 100%.

Statistical analysis

Data obtained were subjected to a one-way analysis of variance (ANOVA) of a completely randomized designed model (SAS 1999). Means that differed were separated using Duncan's Multiple Range Test (Steel and Torrie, 1990).

Results and Discussion

Data on the proximate composition of the unfermented and fermented agro industrial waste products (Tables 1 and 2) revealed that fermentation by *Penicilium spp* significantly (P<0.05) influenced the proximate components of all the samples. *Penicilium spp* significantly (P<0.05) improved the crude protein contents of RB, CRP, SD and POF by 14.19, 35.98, 4.90 and 10.33% respectively with the highest (P<0.05) percentage improvement (35.98%) observed in CRP and least (4.90%) in SD. It was observed that the crude fibre contents of RB, CRP, SD and POF decreased by 8.30, 18.59, 3.95 and 5.62% respectively. The ether extract increased respectively by 4.04, 25.93 and 0.07% for RB, CRP and POF, while there was slight reduction (P<0.05) by 27.28% for SD. *Penicilium spp* significantly (P<0.05) increased ash values of RB by 0.42% and that of CRP by 6.02%, while that of SD and POF were reduced by 2.04 and 6.60% respectively. Respective increases (P<0.05) of 1.27, 0.21, 1.69 and 0.68% in nitrogen free extract (NFE) were recorded for RB, CRP, SD and POF. There was a significant (P<0.05) improvement in the gross energy of all the samples after biodegradation with CRP having the highest (P<0.05) percentage improvement of 24.04%, followed by RB (11.75%), POF (8.59%) and least (3.69%) in SD. However, the detergent fibre values recorded after biodegradation followed a similar pattern with that of the crude fibre which was significantly (P<0.05) reduced after biodegradation. The percentage reduction of neutral detergent fibre (NDF) was significantly (P<0.05) highest (28.31%) in CRP, followed by RB (5.05%), POF (3.47%) and lowest (2.98%) in SD. CRP had the highest (P<0.05) percentage (22.72%) reduction of acid detergent fibre (ADF) after biodegradation compared to 6.85, 4.14 and 3.34% in RB, SD and POF respectively. Similarly, percentage reduction in acid detergent lignin (ADL) after biodegradation was significantly (P<0.05) highest (67.14%) in CRP, followed by RB (15.16%), POF (11.19%) and lowest (9.28%) in SD.

The nutritional improvement observed in all the biodegraded industrial waste samples may be due to the fact that the samples served as media for metabolism

Table 1: The proximate composition of unfermented agro industrial by-products

	Unfermented agro- industrial by-products				
Constituents (%)	**RB**	**CRP**	**SD**	**POF**	**SEM±**
Dry matter	90.02^{d}	90.87^{c}	92.72^{b}	96.54^{a}	0.76
Crude protein	7.19^{a}	2.39^{c}	2.25^{d}	5.52^{b}	0.53
Crude fibre	39.99^{b}	11.42^{d}	74.01^{a}	18.41^{c}	0.98
Ether extract	1.98^{b}	0.27^{d}	0.98^{c}	47.50^{c}	0.84
Ash	19.01^{a}	3.82^{c}	0.98^{d}	7.61^{b}	0.84
Nitrogen free extract	24.85^{b}	72.97^{a}	14.51^{d}	17.46^{c}	0.39
Gross Energy (Kcal/kg)	403.40^{a}	145.03^{c}	139.39^{d}	325.77^{b}	0.82
Neutral detergent fibre (NDF)	65.21^{b}	25.82^{d}	89.91^{a}	37.61^{c}	0.05
Acid detergent fibre (ADF)	46.82^{b}	12.53^{d}	81.30^{a}	24.82^{c}	0.53
Acid detergent lignin (ADL)	16.73^{b}	4.73^{d}	28.92^{a}	14.01^{c}	0.74

^{abcd}: Means in the same row with varying superscripts differ significantly (P<.05)

Table 2: The proximate composition of fermented agro industrial by-products

	Fermented agro- industrial by-products				
Constituents (%)	**RB**	**CRP**	**SD**	**POF**	**SEM±**
Dry matter	89.45^{c}	87.38^{d}	89.76^{b}	94.75^{a}	0.68
Crude protein	8.21^{a}	3.25^{c}	2.36^{d}	6.09^{b}	0.99
Crude fibre	36.91^{b}	9.63^{d}	71.20^{a}	17.43^{c}	0.84
Ether extracts	2.06^{b}	0.34^{d}	0.77^{c}	47.53^{a}	0.72
Ash	19.09^{a}	[illegible].05^{c}	0.96^{d}	7.11^{b}	0.72
Nitrogen Free Extract	23.17^{b}	70.12^{a}	14.46^{d}	16.58^{c}	0.93
Gross Energy (Kcal/kg)	457.11^{a}	190.92^{c}	144.73^{d}	356.40^{b}	0.87
Neutral detergent fibre (NDF)	62.02^{b}	20.10^{d}	87.31^{a}	36.42^{c}	0.04
Acid detergent fibre (ADF)	43.81^{b}	10.20^{d}	81.02^{a}	23.91^{c}	0.63
Acid detergent lignin (ADL)	14.51^{b}	2.83^{d}	26.51^{a}	12.62^{c}	0.84

^{abcd}: Means in the same row with varying superscripts differ significantly ($P<0.05$)

and growth of the inoculated *Pennicilium spp (*Emenalom *et al., 2011)*. Besides, the organism depolymerized the crude fibre contents of the samples thereby converting the products to protein and other useful nutrients. The significant ($P<0.05$) improvement in the gross energy levels of all the samples could be ascribed to the hydrolysis of the crude fibre into components of disaccharides and monosaccharide which enhanced availability and utilization for energy liberation (Faniyi, 2006., Adedire *et al.*, 2012). However, since the optimum growth temperatures of *Penicillium spp* range between 20 to 25°C, the fear of toxicity of the fungus may have been eliminated by oven drying the samples at 70°C for 24 hours during the study.

Conclusion

It can be concluded that solid state fermentation using *Penicillium spp* improved the protein value and reduced the crude fibre contents of rice bran, cassava residual pulp, saw dust and palm oil fibre. The use of *Penicillium spp* in the biodegradation of rice bran, cassava residual pulp, saw dust and palm oil fibre could enhance the bioavailability of the component nutrients and hence could be utilized as alternative ingredients for animal feeds.

References

Adedire, A.O., Oduguwa, O.O., Edema, M.O., Onifade, O.S., Onwuka, C.F.I., 2012. Performance and nutrient utilization of rabbits fed diets based on crop residues fermented with *Rhizopus oligosporus*. *Nig. J. Anim. Prod.* 39(1): 114-121.

A.O.A.C., 2000. *Official Method of Analysis*, 17th Edition. Association of Official Analytical Chemists, Washington D.C. 2000

Dara, I., Hapsari, P., Rashidah, R., Lim, S. H., 2012. Characterization of solid state fermentation culture conditions for growth and mannose production by *Aspergillus niger* USM F4 on rice husk in tray system. *Brit. Biotech. J.* 2(3): 133-145.

Dei, H. K., Rose, S .P., Mackenzie, A .M

and Amarowicz, R. ,2008. Growth performance of broiler chickens feed diets containing shea nut (*Vitellaria paradora*, Gaertn.) meal fermented with *Aspergillus niger*. *Poult. Sci.* 87:1773-1778.

Emenalom, O.O., Etuk, E.B., Esonu, B.O and Nwaini, L.C., 2011. Phytochemical and nutitional evaluation of raw and fermented *Anchonea coridifolia* seed meals on the performance of broiler chicks. *Nig. J. Anim. Prod.* 38(1): 79-85

Faniyi F O. 2006. Optimizing the usefulness of poultry faeces and crop residues for meat, fish and egg production. Inaugural lecture at the Oyo State College of Education, Oyo State. Pg 1-30

Hong, K. L., Lee, C. H., Kon, S. W., 2004. *Aspergillus oryzae* GB-107 fermentation improved nutritional quality of food soya beans. *J. Med. and Food* 7:430-435.

Iyayi, E A. 2004. Changes in the cellulose, sugar and crude protein content s of Agro industrial by-products fermented with *Aspergillus niger, Aspergillus flavus and Penicillium sp. African J. Biotechnol.* 3(3): 155-158.

Iyayi, E. A and Aderolu, A., 2004. Enhancement of the feeding value of some agro industrial by products for laying hens after their solid state fermentation with *Trichoderma viride. African J. Biotechnol.* 3(3): 182-185.

Iyayi, E. A and Lossei, D. M., 2001. *Changes in the carbohydrate fractions of cassava peel following fungal solid state fermentation. J. Food Technol. Africa.* 6(3): 101-103

Nagra, T. S., Sethi, R. P and Chopra, A. K. 1998. Feeding of fermented guar *(Cyanopsis tetrogonaloba* L.taub) meal to broiler chicks. *Indian J. Anim. Prod. and Mgt.* 14:40-44

S .A .S. 1999. *Statistical Analysis System user's guide.* Statistics SAS Institute Inc. Cary, NC 27513, USA.

Steel, R. D. G and Torrie, J .H. 1980. *Principle and procedures of statistics.* McGraw Hill Book corporation, NY.137-139.

Surest, P. V., Sachindra, N .M and Bhastar, N. 2011. Deactylase by *Colletotrichum linemuthianum* ATTC 56676 using different substrates. *J. Food Sci. Technol.* 48(3): 349-356.

Tarhazadesh, Z.2010. Energy generation from the wastes. *Nigeria Compass.* 2(748): 45-48

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