African Journal of Biotechnology Vol. 11(65), pp. 12925-12929, 14 August, 2012
Available online at http://www.academicjournals.org/AJB
DOI: 10.5897/AJB11.126
ISSN 1684–5315 ©2012 Academic Journals

Full Length Research Paper

Enhancement of the feeding value of wheat offal for broiler feeding after its solid state fermentation with *Aspergillus niger*

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Accepted 19 May, 2011

The objective of this study was to investigate the changes in *in vitro* dry matter digestibility (IVDMD) of wheat offal (WTO) after its biodegradation with *Aspergillus niger* and also to determine the effect of degraded WTO on the performance parameters of broiler birds at starter and finisher phases. *A. niger* was used for the biodegradation of WTO. There were five dietary treatments of 33 birds each. Having degraded the WTO, it was observed that there was improvement in crude protein value from 2.43 g/100 gDM to 4.00 g/100 gDM (39.25% improvement). The crude fibre had 28.02% reduction after the degradation. At the starter phase, body weight gain was significantly (P<0.05) higher in the birds fed degraded wheat offal (DWTO). At the finisher phase, feed conversion ratio was significantly (P>0.05) lower in birds placed on DWTO. The relative cost benefit (RCB) showed that economically, the birds placed on DWTO gave better profit margin than the ones placed on the undegraded wheat offal (UWTO). The results revealed that *A. niger* was able to enhance better availability of energy, crude protein and other nutrients which were hitherto encapsulated in the undegraded WTO.

Key words: Wheat offal, *Aspergillus niger*, biodegradation, broiler birds.

INTRODUCTION

The use of fungi for the modification of agro industrial by-products (AIBs) is an important issue because it promotes digestibility of the AIBs and increases the utilization of the mass of the materials. The enzymes released by the fungi when they are cultured on the AIBs make available the “locked up” nutrients in the AIBs which are usually poorly utilized due to the digestive limitations of the monogastric animals (Onilude and Oso, 1999). Plant cell wall contains a variety of polysaccharides, the distribution of which varies within primary and secondary cell walls. The polymers are interlinked with each other by covalent or non-covalent linkages. Depending on the primary structure of polysaccharides, various enzymes activities are required to hydrolyze the AIBs. The consequent action of the fungi may also improve the accessibility of the substrates if it affects the interlinkages of the polysaccharides within the cell wall matrix (Choct et al., 1995). High feed cost is a major constraint in sub Saharan African industry. This has caused instability in the livestock business in the past few years as many poultry farm businesses were almost paralyzed due to low or no profit margin. Since the monogastric livestock industry constitutes the largest users of the conventional feedstuffs which have elicited competition with human, it is therefore imperative to find alternative feed sources to the expensive ones. They are found in abundance at agro-industrial processing centres. But the use of these AIBs is hindered by their fibrous nature (Iyayi and Losel, 2001). Fibre primarily contains non starch polysaccharides (NSPs) which form part of the cell wall structure. The role of fibre in monogastric diets

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has attracted much attention in recent years due to the fact that: (a) the soluble NSPs elicit antinutritive effects and (b) the utilization of NSPs as a feed material in monogastrics is very poor. The term NSPs covers a large variety of polysaccharides molecules excluding α-glucans (starch). Some examples of NSPs are: cellulose, pentosans (arabinoxylans and xylans), β-glucans, pectin, mannans, arabinans, galactans and xyloglucans (Annison and Choct, 1991). The major detrimental effects of NSPs are associated with their viscous nature and physiological effects on the digestive tract. The viscosity of the NSPs depends on their solubility and molecular weights (Vahouny, 1982). Thus, the AIBs could be exogenously weakened when fungi are cultured on them in order to split the β-1,4 linkages in the hemicellulolytic xyloglucans of their primary cell wall (Bedford et al., 1991). Wheat offal is obtained from the wheat grains through the abrasive action of a blade-bearing rotating drum inside the machine. The offal comes out through a sieve with rectangular slits of 1 x 10 mm, while the polished grains come out through another opening in the machine. Man does not presently use it for food and so it has a potential as an animal feedstuff. Cereal offal such as wheat offal consists mainly of the aleurone layer and some adultrant of germs and endosperm.

Wheat offal (WTO) still contains considerable amounts of energy and proteins which may be present as intracellular compounds (Harricane and McCance, 1976; Liu and Baidoo, 2005). It is a potential valuable and renewable resource which finds application in various areas that include use as animal feed ingredients. Efficient utilization of WTO is only possible after total or partial conversion of the complex plants materials into peptides or amino acids, oligo or monosaccharide; this can be achieved through the instrumentality of fungal biodegradation.

Fungi have been reported as effective means of breaking down NSP of AIBs to increase their nutritive value (Lawal et al., 2005). The objective of the study was to investigate the ability of *Aspergillus niger* to break down the fibrousness of WTO and its consequent effect on the bioavailability of the nutrients hitherto hidden in the undegraded WTO for broiler production.

MATERIALS AND METHODS

Wheat offal was obtained from the feed milling industry in Ibadan, Nigeria. It was dried to constant weight at 60°C. Dried WTO was autoclaved at 121°C for 15 min. The autoclaved WTO was then inoculated with *A. niger* under aseptic condition after adjusting its moisture level to 25%. After 7 days, the biodegradation reaction was stopped and the material was dried (Iyayi and Losel, 2001). Samples were then withdrawn for proximate analysis using the method of AOAC (Vol. II, 1995). The *A. niger* used was obtained from Department of Pharmaceutical Microbiology, University of Ibadan, Nigeria. The characterization of the obtained *A. niger* was known by the use of manual of Barnett and Hunter (1992). A total of 165 day old broiler chicks (Anak strain) were used for the feeding trials. There were five dietary treatment groups of 33 birds each and three replicates of 11 birds each. Diet 1 contained neither degraded nor undegraded WTO. Diet 2 contained 7% undegraded WTO, while diets 3, 4 and 5 contained 3, 5 and 7% levels of *A. niger* degraded WTO. The experimental design used was completely randomized design. Data were analyzed statistically using the analysis of variance (ANOVA) technique of Steel and Torrie (1990). Where statistical significant differences were observed, the treatment means were compared by using statistical analysis system (SAS, 1999).

RESULTS AND DISCUSSION

The results of changes in the levels of protein, crude fibre, detergent fibres, gross energy and ash in wheat offal after biodegradation with *A. niger* are presented in Table 1. After biodegradation, it was observed that there was improvement in crude protein value from 2.43 g/100 gDM to 4.00 g/100 gDM (39.25%). The ash also increased from 2.33 to 3.58 g/100gDM which was 34.91%. The crude fibre and the nutrient detergent fibre were reduced after the degradation. The crude fibre, cellulose and acid detergent lignin had 28.02, 19.33 and 11.68% reduction, respectively, after degradation. At the starter phase, body weight gain was significantly ($P<0.05$) higher in the birds fed degraded DWTO. At the finisher phase, feed conversion ratio was significantly ($P>0.05$) lower in birds placed on DWTO. The relative cost benefit (RCB) shows that economically, the birds placed on DWTO gave better profit margin than the ones placed on the UWTO. The ability of fungi to degrade fibre has been reported by other workers (Ofuya and Nwajiuba, 1990; Iyayi and Losel, 2001). The work of Ofuya and Nwajiuba revealed successful degradation of cassava peel (fibrous by-products of cassava tuber processing) by *Rhizopus* sp*.* The authors reported that over 35.00% of the original cellulose content of the substrate was lost in solid state fermentation. *A. niger* grown on rye grass straw produced similar results as reported by Han (1978). The increase in crude protein value of the degraded WTO was partly due to ability of the enzymes to increase the bioavailability of the protein hitherto encapsulated by the cell. Many workers have reported similar increase in protein content. Bachtar (2005) reported increase in crude protein when *A. niger* was inoculated on sago fibre and cassava fibre, resulting to 16.5 and 18.5% protein increase, respect-tively. The author did it for cocoa shell and 21.9% increase in crude protein was recorded. The increase in the energy value of the degraded WTO may be due to the ability of *A. niger* to break the starch and the non starch polysaccharides into monomer sugars which are then easily metabolized (Iyayi and Aderolu, 2004; Balagopalan, 1996). The improvement seen in the minerals (ash) bioavailability may be explained by the ability of *A. niger* to elicit enzyme like phytase which increases the bioavailability of phytate phosphorus and this may invariably lead to improvement in the bioavailability of other minerals that are susceptible to chelation such as Zn, Mn, Ca, Cu and Fe (Ferket, 1993). As observed in Tables 2 and 3, body weights of the

Table 1. Proximate and detergent fibre analysis of the undegraded and degraded wheat offal (g/100 gDM).

Parameter	Undegraded wheat offal	Degraded wheat offal
Dry matter	87.53	89.11
Crude protein	2.43	4.00
Ash	2.33	3.58
Ether extract	0.17	0.13
Crude fibre	11.60	8.35
Nitrogen free extract	84.14	86.19
Gross energy (kcal/kg)	4.73	5.86
Cellulose	8.12	6.55
Hemicellulose	5.33	4.23
Neutral detergent fibre	2.11	1.85
Acid detergent fibre	3.16	2.90
Acid detergent lignin	7.02	6.20

Table 2. Performance of broiler starter fed diets containing undegraded and degraded wheat offal.

Parameter	Control	7% UWTO	3% DWTO	5% DWTO	7% DWTO	SEM
Body weight gain (g/b/d)	30.98^{c}	28.19^{d}	32.23^{b}	34.70^{a}	35.62^{a}	1.18
Feed intake (g/b/d)	65.92^{c}	74.22^{a}	68.74^{b}	69.62^{b}	69.30^{b}	3.37
Feed conversion ratio	2.13^{a}	2.63^{ab}	2.13^{b}	2.00^{ab}	1.95^{ab}	0.069
Efficiency of feed utilization	0.46^{b}	0.37^{b}	0.46^{b}	0.49^{a}	0.51^{a}	0.0073
Mortality (%)	1	0	1	0	1	-
Relative cost benefit (%)	0.00	4.37	5.11	5.27	5.10	-

^{a,b,c}, Means in the same row with different superscripts differ significantly (P<0.05); UWTO = undegraded wheat offal; DWTO = degraded wheat offal.

Table 3. Performance of broiler finisher fed diets containing undegraded and degraded wheat offal.

Parameter	Control	7% UWTO	3% DWTO	5% DWTO	7% DWTO	SEM
Body weight gain (g/b/d)	59.53^{c}	52.27^{d}	62.29^{b}	65.10^{a}	66.61^{a}	2.15
Feed intake (g/b/d)	167.81^{c}	171.53^{b}	168.79^{c}	181.58^{a}	181.21^{a}	8.39
Feed conversion ratio	2.81^{b}	3.28^{a}	2.70^{b}	2.78^{b}	2.70^{b}	0.017
Efficiency of feed utilization	0.35^{a}	0.30^{b}	0.36^{a}	0.35^{a}	0.36^{a}	0.005
Mortality (%)	1	0	0	0	1	-
Relative cost benefit (%)	0.00	3.21	3.84	4.31	4.12	-

^{a,b,c}, Means in the same row with different superscripts differ significantly (P<0.05); UWTO = undegraded wheat offal; DWTO = degraded wheat offal.

fed degraded wheat offal improved at the starter and finisher phases. This may be due to the fact that viscosity by the feed along the gastro intestinal tract of the birds was prevented. Undegraded agro industrial by-products are able to increase viscosity of the digesta and the transit time in the gastrointestinal tract which can lead to increase in the size and stability of the unstirred layer at the mucosal surface of the digestive tract. This reduces the contact between the feed and the digestive enzymes and slows the uptake in the foregut of released sugars, amino acids and lipids, resulting in the impaired digestibility of the major nutrients (Bedford, 1995; Van der Klis et al., 1995). This may result in poor weight gain by birds fed undegraded agro industrial by-products like wheat offal. There is also cumulative evidence that increasing viscosity of the digesta promotes bacterial proliferation, which is to the detriment of overall digestive efficiency and by implication, the body weight gain by the birds (Choct et al., 1995). The improvement in the utilization of the biodegraded wheat offal may ultimately result in improvement of the body weights of the fed birds. Feed conversion ratio was best (1.95 and 2.70) at

Table 4. Gross composition (kg) of the experimental diets at starter phase containing undegraded and degraded wheat offal.

Ingredient	Control	7% UWTO	3% DWTO	5% DWTO	7% DWTO
Maize	52.00	56.00	53.00	54.00	56.00
UWO	-	7.00	-	-	-
DWO	-	-	3.00	5.00	7.00
Corn offal	8.30	0.30	7.30	5.30	2.30
Groundnut cake	9.20	7.70	7.70	7.20	7.20
Soya bean meal	24.00	20.00	20.00	19.00	18.00
Fish meal	3.00	5.50	5.50	6.00	6.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00	1.00
premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
ME (kcal/kg)	2969.86	2962.23	2960.68	2961.04	2967.52
Crude protein (%)	22.49	22.64	22.67	22.77	22.72

ME = Metabolizable energy; UWTO = undegraded wheat offal; DWTO = degraded wheat offal. Provided per kg diet: 5000 IU vitamin A; 1000 IU vitamin D; 0.8 mg vitamin E; 0.4 mg menadione K3; 1.2 mg riboflavin; 1.0 mg pantothenic acid; 0.004 mg vitamin B12; 3 mg niacin; 4 mg vitamin C; 112 mg choline; 24 mg manganese; 8 mg iron; 0.048 mg selenium; 5 mg antioxidant, BHT.

Table 5. Gross composition (kg) of experimental diets at finisher phase containing undegraded and degraded wheat offal.

Ingredient	Control	7% UWTO	3% DWTO	5% DWTO	7% DWTO
Maize	53.00	58.00	55.00	57.00	58.00
UWO	-	7.00	-	-	-
DWO	-	-	3.00	9.30	6.30
Corn offal	13.30	6.30	11.30	5.30	2.30
Groundnut cake	9.20	9.20	9.20	9.20	9.20
Soya bean meal	18.00	13.00	15.00	13.00	13.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00	1.00
premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
ME(kcal/kg)	2965.08	2964.01	2964.58	2961.72	2968.20
Crude protein (%)	20.62	20.06	20.09	20.05	20.00

ME = Metabolizable energy, UWTO = undegraded wheat offal, DWTO = degraded wheat offal. Provided per kg diet: 5000 IU vitamin A; 1000 IU vitamin D; 0.8 mg vitamin E; 0.4 mg menadione K3; 1.2 mg riboflavin; 1.0 mg pantothenic acid; 0.004 mg vitamin B12; 3 mg niacin; 4 mg vitamin C; 112 mg choline; 24 mg manganese; 8 mg iron; 0.048 mg selenium; 5 mg antioxidant, BHT.

the starter and finisher phases, respectively at 7% DWTO. The improvements observed in feed conversion ratio by birds placed on DWTO can be explained by the effect of fungal enzymic degradation conferred on the target substrate. Tables 4 and 5 show the gross composition of diets at starter and finisher phases. They were formulated to ensure that the diets were isocaloric and isonitrigenous. Lawal (2007) suggested that any processing techniques aimed at increasing the level of utilization of AIBs should be simple and must not increase the cost of production. The biodegradation process achieved this by producing the nutritionally improved biodegraded wheat offal. The RCB observed in this work at both starter and finisher phases showed better or positive results.

Conclusion

Fungal degradation of wheat offal showed decreased crude fibre level, improved crude protein content and increased ash (minerals) bioavailability via the depolymerization process through solid state fermentation done by the enzymes released by the fungus (*A. niger*) in an attempt to feed on the wheat offal. Furthermore, this work showed that it is economically expedient to use degraded wheat offal in feeding the broiler birds than using the undegraded wheat offal.

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