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Use of *Aspergillus niger* for improving the feeding value of rice offal

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Undegraded and degraded rice offals (RO) were used to compound rations for broiler birds for eight weeks. The undegraded was used at 7% inclusion level and the degraded was used at 3, 5 and 7% inclusion levels. A hundred and sixty five (165) day old chicks were randomly selected and allotted to five (5) treatments. Each treatment had three replicates and each replicate had eleven birds. *Aspergillus niger* was inoculated into RO through solid state fermentation for a period of seven (7) days and this was used as the degraded sample. There was improvement in the crude protein and ether extract of the degraded sample, while the crude fibre content reduced. The crude protein increased from 8.79 to 12.24% while the crude fibre reduced from 15.89 to 10.82% after biodegradation. The results from the feeding trials showed significant (P< 0.05) differences in the average feed intake and average body weight gain at the starter phase. The highest feed consumption was found in treatment 5 which contained 7% degraded RO (DRO) and it was 65.11 g/b/d. At the finisher phase, there were significant (P<0.05) differences in both the average feed intake and the average body weight gain of the birds. The highest feed intake was found in treatment 5 and it was 201.84 g/b/d. The highest body weight gain was also found in treatment 5 and it was 75.52 g/b/d. The relative cost benefit (RCB) showed that economically, the birds placed on degraded rice offal (DRO) gave better profit margin than the ones placed on the undegraded rice offal (URO). The results reveal that *A. niger* was able to improve the energy, crude protein and other nutrients in rice offal which will bring economic benefits to farmers.

Key words: *Aspergillus niger*, rice offal, degraded, undegraded, nutrient contents, feed improvement.

INTRODUCTION

The chief problem of poultry in the Sub-saharan countries today is the cost of feed ingredients. This challenge has reduced the rate of expansion of the poultry industry and has added to the low level of animal protein nutrition of their citizens. Attempts to reduce the high cost of feeds and therefore the cost of poultry products have concentrated on using feeds formulated from available and cheap alternatives and unconventional feedstuffs. Research into the use of cheaper industrial by-products and wastes at various levels of dietary inclusion for poultry has therefore been intensified in the last few years to determine their efficiency of utilization in terms of

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Abbreviations: GIT, Gastro intestinal tract; **NSPs,** non-starch polysaccharides; **SSF,** solid state fermentation; **RO,** rice offal; **NFE,** nitrogen free extract; **URO,** undegraded rice offal; **DRO,** degraded rice offal; **AIBs,** agro-industrial products.

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

Parameter	Undegraded rice offal (g/100 gDM)	Degraded rice offal (g/100 gDM)
Dry matter	88.68	90.03
Crude protein	8.79	12.42
Ash	10.31	12.78
Ether extract	0.14	0.12
Crude fibre	15.89	10.82
Nitrogen free extract	62.87	67.86
Gross energy (kcal/kg)	3.45	4.72
Cellulose	7.41	6.48
Hemicellulose	4.58	3.27
Neutral detergent fibre	2.41	1.35
Acid detergent fibre	6.13	4.23
Acid detergent lignin	3.85	2.14

growth and production. There is the need to harness the potentials of agro-industrial by-products and other unconventional feed resources (Edache et al., 2005). Ordinarily, poultry cannot utilize high fibre diets because it lacks the digestive framework that can elaborately digest large amounts of agro-industrial by-products. Park et al. (2011) reported that fibrous agro industrial by-products (like rice offal (RO) plays an important role in the maintenance of the normal structure and function of the intestinal mucosa. However, other workers, Anusith et al. (2012) and Isikwenu et al. (2005) have implicated crude fibre as a factor depressing nutrient digestibility, absorption, bioavailability and utilization. Crude fibre entraps nutrients in insoluble complex which it forms in the cell wall of plants and this resists the digestion by the endogenous enzymes in the gastro intestinal tract (GIT) of poultry and other non-ruminant animals (Kosseva, 2013). Viscosity-promoting potential of crude fibre also reduces overall digestive and absorptive efficiency by preventing nutrients from being available at the absorptive site in the intestinal mucosa (Iyayi et al., 2005). There is therefore the need to render the non-starch polysaccharides (NSPs) in fibre utilizable by monogastric animals. One of the ways to achieve this is through the instrumentality of biotechnological tool-solid state fermentation (SSF). Biodegradation of the agro industrial by products, in this case, rice offal, by fungus will lead to the production of enzymes which will in effect break specific linkages in the long chain polysaccharides, releasing substances which the endogenous enzymes of the monogastric animals can break down further so that the nutrients can be absorbed and utilized. In other words, fungal biodegradation of agro industrial by products complements the birds' own digestive enzymes, working with them to improve their efficiency. In this work, the fungus used was *Aspergillus niger*. It has the potential of splitting the β-1, 4 linkages in the hemicellulolytic xyloglucans of their primary cell wall and thereby reducing the viscosity of the gut contents, thereby enhancing nutrient absorption (Lirong et al., 2007; Kosseva, 2011). Rice offal is one of the agro-industrial by-products that is readily available and cheap and can be used to reduce the cost of poultry diets. It is the ultimate waste in rice processing consisting of husk, bran and small particles of rice. Rice constitutes the principal food of almost half of human race. Rice grain itself is not used as animal feed, but the offal which constitutes 8% of rice is used (Iorgyer et al., 2008). The present study was therefore conducted to investigate the effects of inclusion of graded levels of biodegraded rice bran on the growth performance of broilers at both starter and finisher phases.

MATERIALS AND METHODS

Rice offal was obtained from the feed milling industry in Iwo, Osun State, Nigeria. It was dried to constant weight at 60°C. Dried rice offal was autoclaved at 121°C for 15 min. The autoclaved rice offal 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 Biological Science, Bowen University, Iwo, 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 rice offal. Diet 2 contained 7% undegraded RO, while diets 3, 4 and 5 contained 3, 5 and 7% levels of *A. niger* degraded RO. 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

Chemical analysis of undegraded and degraded rice offal is presented in Table 1 while Tables 2 and 3 show the gross composition (kg) of experimental diets at starter

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

Parameter	Control	7% URO	3% DRO	5% DRO	7% DRO	SEM
Body weight gain (g/b/d)	22.11[a]	20.20[b]	22.40[a]	22.90[a]	23.60[a]	1.10
Feed intake (g/b/d)	59.22[ab]	58.00[b]	58.40[b]	62.40[b]	65.11[a]	2.12
Feed conversion ratio	2.68	2.74	2.61	2.72	2.76	0.052
Efficiency of feed utilization	0.37	0.36	0.38	0.37	0.36	0.0054
Mortality (%)	1	1	0	0	1	-
Relative cost benefit (%)	0.00	5.01	5.81	5.50	5.22	-

a,b,c, Same row with different superscripts differ significantly (P<0.05); URO, undegraded rice offal; DRO, degraded rice offal.

Table 3. Performance of broiler finishers fed diets containing undegraded and degraded rice offal.

Parameter	Control	7% URO	3% DRO	5% DRO	7% DRO	SEM
Body weight gain (g/b/d)	66.33[d]	64.64[e]	69.44[c]	73.28[b]	75.52[a]	2.22
Feed intake (g/b/d)	177.66[ab]	164.37[c]	175.20[b]	193.44[a]	201.84[a]	7.41
Feed conversion ratio	2.67	2.54	2.52	2.63	2.67	0.015
Efficiency of feed utilization	0.37	0.39	0.40	0.38	0.37	0.004
Mortality (%)	1	0	1	0	1	-
Relative cost benefit (%)	0.00	5.12	5.92	5.88	5.41	-

a,b,c, Same row with different superscripts differ significantly (P<0.05); URO, undegraded rice offal; DRO, degraded rice offal.

and finisher phases respectively. The results show that the effects of fungal biodegradation resulted in the changes observed. The crude protein increased from 8.79 to 12.42% after fermentation. This same pattern was observed in ash, nitrogen free extract (NFE) and gross energy. The ash increased from 10.31 to 12.78 g/100 gDM which was 23.95%. The gross energy improved from 3.45 to 4.72 kcal/kg this indicated 26.91% improvement. However, the crude fibre and the detergent fibre levels reduced after fungal fermentation. For instance, the crude fibre reduced from 15.89 to 10.82 g/100gDM and the detergent fibres followed the same trend. Besides, the ether extract (oil) also reduced after biodegradation. Performance of the birds at the starter phase is presented in Table 4. It was observed that there were significant (P<0.05) differences among the feed intake and the body weight gained. The body weight gain increased from 20.20 when birds were fed 7% undegraded rice offal (URO) to 23.60g/b/d when they were fed degraded rice offal (DRO). Feed intake also improved from 58.00 to 65.11 g/b/d when birds were fed 7% URO and DRO, respectively. Performance of broilers at finisher phase is presented in Table 5. The same trend was observed as the performance of the birds for the body weight and feed intake improved for the birds that were placed on the treatments with the degraded rice offal. The relative cost benefits (RCB) revealed that the birds on DRO gave a better economic gain than the ones placed on URO treatment. The results showed that *A. niger* could possibly have broken down the crude fibre and the crude lipid present in the rice offal and then converted the products to other useful nutrients like protein and other essential substances. Increase in the gross energy after biodegradation could possibly be because of the oxidization of the ether extract. Lipids when oxidized have the potential of yielding considerable amount of energy for the organism.

In the same corollary, Villas-Boas et al. (2003) treated apple pomace using *Candida utilis* followed by *Pleurotus ostreatus* in solid state fermentation (SSF). They found that after *C. utilis* fermentation, protein and mineral content increased 100 and 60 % respectively accompanied by 8.2% increase in digestibility, while sequential fermentation with *C. utilis* and *P. ostreatus* achieved a high protein level with 500% of crude protein enrichment after 60 days of fermentation, as well as a considerable increase in the mineral content. Thus, the utilization of SSF, which requires sophisticated technology and is of low cost (Aderemi and Nworgu, 2007; Kang et al., 2004; Khattak, 2002; Zhuy et al., 2011), offers the potential of improving the nutritional value of agro-industrial products (AIBs). There was better weight gain by the birds placed on DRO than the ones placed on UFO at both starter and finisher phases. This may be due to the cocktail of enzymes released by the *A. niger* in the course of biodegrading the carbon source (rice offal). Possibly, the mixture of enzymes broke the bonds of polymers which essentially make up the fibrous rice offal and modify the bonds in constituent polysaccharides, for example, cellulose and thus releasing nutrients directly or providing additional substrates for the birds own endogenous gut enzymes. Biodegradation of rice offal by *A. niger* works by “unlocking” the “encapsulated” nutrients bound by the cell walls thereby reducing the viscosity and thus

Table 4. Gross composition (Kg) of experimental diets at starter phase containing undegraded and degraded rice offal.

Ingredient	Treatment 1 (0% RO)	Treatment 2 (7% URO)	Treatment 3 (3% DRO)	Treatment 4 (5% DRO)	Treatment 5 (7% DRO)
Maize	52	56	53	54	56
URB	-	7.0	-	-	-
DRB	-	-	3.0	5.0	7.0
Corn offal	5.8	0.3	7.3	5.3	2.3
GNC	9.0	7.5	7.5	7.0	7.0
SBM	24	20	20	19	18
Fish meal	5.5	5.5	5.5	5.5	5.5
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
ME	2970.92	2966.99	2965.69	2968.21	2967.88
%CP	22.50	22.56	22.60	22.71	22.68

RB, Rice offal; URO, undegraded rice offal; DRO, degraded rice offal. Micro-mix broiler premix supplied the following per 2.5 kg: Vitamin A: 12,500,000.00 (I.U); vitamin D3: 5,500.00 (Mg); vitamin B1: 3,000.00 (Mg); Niacin: 5,500.00 (Mg); calcium pantothenate: 11,500.00 (Mg); vitamin B6: 500.00 (Mg); zinc: 80,000.00 (Mg); copper: 8,500.00 (Mg); iodine: 1,500.00 (Mg); colbalt: 300.00 (Mg); selenium: 120.00 (Mg); anti-oxidant: 120,000.00 (Mg).

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

Ingredients	0% RO	7% URO	3% DRO	5% DRO	7% DRO
Maize	54	57	56	57	57
URB	-	7.0	-	-	-
DRB	-	-	3.0	5.0	7.0
Corn offal	12.4	6.5	11.0	9.1	6.5
GNC	9.2	9.2	9.2	9.2	9.2
SBM	17.7	13.6	14.1	13	13.6
Fish meal	3	3	3	3	3
Bone meal	2	2	2	2	2
Oyster shell	1	1	1	1	1
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.1	0.1	0.1	0.1	0.1
Methionine	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100
ME	2966.06	2965.22	2967.80	2962.22	2967.31
%CP	20.55	20.08	20.07	20.09	20.05

RO, Rice offal; URO, undegraded rice offal; DRO, degraded rice offal. Micro- mix broiler premix supplied the following per 2.5 kg: Vitamin A: 12,500,000.00 (I.U); vitamin D3: 5,500.00 (Mg); vitamin B1: 3,000.00(Mg); niacin: 5,500.00 (Mg); calcium pantothenate: 11,500.00 (Mg); vitamin B6: 500.00 (Mg); zinc: 80,000.00 (Mg); copper: 8,500.00 (Mg); iodine: 1,500.00 (Mg); colbalt: 300.00 (Mg); selenium: 120.00 (Mg); anti-oxidant: 120,000.00 (Mg).

improving the nutrient absorption by the birds.

Furthermore, growth of fungi has the potential of neutrallizing anti-nutritional factors such as β-glucans and the products as a whole supplements the under-developed enzymes systems of chicks. In addition, the increase in body weight gain may be due to the fact that fungal biodegradation of AIBs has the potential of improving digestion, increase feed intake, reduce microbial fermentation, reduce transit time in the gastro intestinal tract and reduce endogenous losses; all these will invariably positively influence the body weight gain by the birds (Lawal et al., 2012a, b; Akinfemi and Ogunwole, 2012). The relative cost befit observed in this work shows that fungal biodegradation of rice offal improved by *A. niger* through the instrumentality of solid state fermentation increases the farmers' economic gain.

Conclusion

A. niger growth on rice offal showed decrease in neutral detergent fibre, acid detergent fibre, neutral detergent lignin, crude fibre, ether extract, cellulosic and hemicellulosic contents but increased the crude protein and gross energy content. Broiler birds placed on degraded rice offal gained more weight and gave the best relative cost benefit. This work has therefore attempted to show that fungal degradation of agro industrial by products will lead to increase in bioavailability of nutrients in the agro industrial by products and that the monogastrics can subsequently digest them and this will enhance profitability in poultry industry.

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