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Processing of Feather Meal by Solid State Fermentation

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Abstract: Effects of biological and physical treatments of feather meal was evaluated in a completely randomized design model. Different samples were prepared using fungus specie, *Rhizopus oligosporus* (T_1), batch hydrolyzer (T_2) and the untreated control (T_3). Feather meal was fermented with *Rhizopus oligosporus* in a solid state fermentation for 7 days while the steam pressure used for the batch hydrolyzer was 285 kPa. The changes in the proximate composition and fibre fractions were determined at the end of the experimental period. The results revealed increased ($p<0.05$) crude protein and ether extract contents compared to the means of the batch hydrolyzer (T_2) and the untreated control treatment (T_3). Protein enrichment was highest for the *Rhizopus* treated sample (T_1) followed by the batch hydrolyzer (T_2) and lowest for the untreated control sample (T_3). Contrarily, the fibre fractions (ADF, NDF, Lignin) decreased in the fungus (*Rhizopus oligosporus*) treated sample compared to the batch hydrolyzer and the untreated samples which are similar ($p>0.05$). The ether extract ranked ($p<0.05$) T_2(7.50) > T_1(5.75) > T_3 (3.25). The Acid Detergent Soluble Nitrogen (ADSN) was 0.82% (T_1) 0.60% (T_2) and 0.20% (T_3). While the Pepsin Digestible Protein (PDP) was 0.65 (T_1) compared to 0.81 (T_2) and 0.18 (T_3). The study demonstrated that solid state fermentation of feather meal with fungus (*Rhizopus oligosporus*) increased the protein and ether extract contents while the crude fibre fractions are decreased, all of which are limiting nutrients in livestock nutrition. Overall, fungus *Rhizopus oligosporus* appeared to be the best of the methods studied and it seems to be useful for current purpose.

Key words: Feather meal, *Rhizopus oligosporus*, batch hydrolyzer, proximate composition, pepsin digestible protein

INTRODUCTION

Over one million tonnes of feather are produced yearly in the United States and as the consumption of poultry meat increases so will the production of this valuable raw material (Chandler, 2007). Additionally, approximately, 950 metric tons of feathers are generated per year in Germany (EDFA, 2007).

Feathers are among the most complex structured organs found in vertebrates. It is an integumentary appendage, formed by controlled proliferation of cells in the epidermis, or outer skin layer that produce keratin proteins. The β-keratins in feathers, beak and claws are composed of protein stands hydrogen bonded into β pleated sheaths, which are further twisted and cross linked by disulfide bridges into structures even tougher than the α-keratins of mammalian hair, horns and hoof (Gregory *et al*., 1979). Unprocessed feathers are high in crude protein, but are highly indigestible due to the aforementioned keratin which contains a high amounts of cystine (approx 10%), the cross linking of cystine is why the crude protein fraction of feather is highly indigestible.

The crude protein content of feather does not suffer from the demerit of anti-nutritional factors like tannin, lectin saponin, glucosinolates and trypsin inhibiting factor. However, the crude protein content of raw feathers are relatively insoluble with poor digestibility of about 5% due probably to the high keratin content and the strong disulphide bonding of the amino acids (Chandler, 2007) hence, processing of the waste resulted into serious problem. In order to avoid wasting resources, the waste should be processed, recycled and used for secondary purposes as a raw material. The most common processing of feather is the hydrolysis method. Hydrolyzation is accomplished by cooking the feather with steam. This was previously done in batch cookers but currently the use of continuous hydrolyzer is advancing (Vincent Corporation, 1998). It is worth noting that the most vital factor affecting the quality of hydrolyzed

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poultry feather is the extent of hydrolyzation, if less than 75% of the crude protein content is digestible by pepsin digestibility method hence hydrolyzation was incomplete and protein quality is reduced (Ewing, 1997). Therefore, the thrust of this study was to evaluate the efficacy of the biological and physical treatments of feather meal so as to maximize its nutritional quality for livestock.

MATERIALS AND METHODS

Feather meal: Raw feathers were collected from broiler raised and slaughtered between June and September, 2007, at the Department of Animal Production, University of Ilorin, Nigeria. The raw feathers were washed with a commercial laundry detergent, rinsed well with good clean water. While any unwanted materials other than the feather was removed. The cleaned feathers were dried in a forced laboratory oven and later milled.

The raw, cleaned, milled feather meals were divided into three treatment groups with each treatment consisting of 10 replicates and each replicate weighing 500 g. T_1 was the fungus treated sample while T_2 was the batch hydrolyzer sample and T_3 was the control (untreated) sample.

Fungus used: *Rhizopus oligosporus* used for this experiment was obtained from the culture collection of the Department of Animal Production, University of Ilorin, Nigeria. The test organism was cultivated on Potato Dextrose Agar (PDA) containing in Petri-dishes for a 10 day period, when the organism enveloped the agar.

The spores of *Rhizopus oligosporus* were harvested with Tween 80 solution (10 mL, 0.01% v/v) and later adjusted between 10^7 and 10^8 spores per mL with sterile water. Each of the sample (n = 10) was inoculated with 5 mL of the spore suspension. In about 7 days, the fungus had covered the surface of the substrate. The fungus treated feather meals (T_1) were later oven dried in a forced laboratory oven at 70°C 48 h in preparation for chemical analysis. At the end of the 48 h the samples were removed from the oven, milled and packed in well labeled polyethylene bags.

Batch hydrolyzer: The feather meals (T_2) was subjected to a steam pressure in a batch hydrolyzer at an average pressure of 283 kPa, with less agitation and long residence time of 118 min.

Chemical analysis: Pepsin digestibility of the feather meals (T_1, T_2 and T_3) were determined by using 0.2% Pepsin solution (AOAC, 1984). The proximate composition was determined by the method of AOAC (1990) while the fibre fraction was done by the method of VanSoest (1963). The acid detergent soluble nitrogen was determined by first preparing the acid detergent insoluble (ADF) while the nitrogen content of the remaining fiber was determined (AOAC, 1990) and subtracted from the total nitrogen content of the samples.

Statistical analysis: All data collected were subjected to analysis of variance of a completely randomized design model (Steel and Torrie, 1980) while treatment means were separated using Duncan (1955) multiple range test.

RESULTS AND DISCUSSION

The crude protein was significantly highest in T_1 (Fungus treated) compared to the means of T_2 and T_3 which are similar ($p>0.05$) (Table 1). The highest crude protein of T_1 could be due partly to the addition of microbial protein during the fermentation process (Nout and Rombouts, 1990; Belewu *et al*., 2006). The increased crude protein content post incubation agreed with the previous studies (Yang *et al*., 1993). Since no external source of nitrogen was supplied in this study, there could only be the addition of microbial protein (Abu *et al*., 2000).

The crude fibre content was lowest in T_1 compared to the values of T_2 and T_3. The lowest crude fibre content of T_1 might be due to the action of the fungus on the feather meal. This confirms the assertion of Jacquline and Visser (1996) who recorded a similar reduction of crude fibre.

The lowest content of crude fibre for T_1 could be due probably to the action of the fungus which could have used the lignin for their own growth.

The ether extract content of T_1 was highest compared to the means of T_3 (control). This shows that the fungus has a better lipogenic capacity because the ether extract was depleted during incubation period. Similar fungus was used in the preparation of Tempe in Indonesia with increasing lipase (Nout and Rombouts, 1990).

Table 1: Proximate composition of biologically and physically treated feather meals*

	Treatments			
Parameters (%)	1	2	3	±SEM
Dry matter	80.73^a	40.98^b	76.25^c	6.25*
Crude protein	75.29^a	61.25^b	60.28^b	4.32*
Crude fibre	3.80^a	9.75^b	10.90^c	2.13*
Ether extract	5.75^a	7.50^b	3.25^c	1.10*
Lignin	9.30^a	12.89^b	18.70^c	1.75*
NDF	47.65	46.20	48.90	2.10NS
ADF	15.20^a	17.85^b	18.25^b	1.56*
Acid detergent soluble N	0.82^a	0.60^b	0.20^c	0.08*
Pepsin Digestible Protein (PDP)	0.65^a	0.80^b	0.18^c	0.41*

*Means of 10 determinations, Means along the rows with different superscripts are significantly different ($p>0.05$), SEM: Standard Error of the Mean, NS: Not Significantly different ($p>0.05$)

Conversely, the lignin content was reduced by 50 and 28% in T_1 compared to that of the control (T_3) and T_2, respectively. The reduction in the lignin content (T_1) presumably may be due to enzymatic action of the fungus. This was consistent with the study reported elsewhere (Jacquline and Visser, 1996). Additionally, the fungus showed ligninolytic activity due to the high lignin reduction. The lignin-carbohydrate complex is usually chemically modified during microbial attack (Chanrd and Richard, 1975) and is not recovered in the acid detergent residue.

The greater lignin content of T_2 could be due to the action of steam pressure which could have broken the barrier (lignin) without actually removing the lignin content. Other fibre fractions (ADF, NDF) followed similar trend.

The value of the Pepsin Digestible Protein (PDP) ranged from 0.18 to 0.81. The higher PDP value of (0.65) T_1 shows that the feather meal treated with *Rhizopus oligosporus* had a higher nutritional value compared to the highest value of 0.80 (T_2) and lowest value of 0.18 (T_3).

The value of 0.65 reported for T_1 fell within the values recorded by Association of American Feed Control Officials (1994) and Latshaw *et al.* (1994). However, the value of PDP reported for T_2 revealed that the protein was locked within the cross linked disulfide bridge of cystine present in feather meal. The value of the Acid Detergent Soluble Nitrogen (ADSN) followed similar trend as the PDP.

CONCLUSION AND IMPLICATION

This study demonstrated that solid state fungal fermentation of feather meal enhanced the protein and lipid concentrations while the fibre content was reduced. This compositional improvement would translate to added nutritional value for livestock; it will also help in solving the problem of environmental pollution.

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