APPARENT DIGESTIBILITY COEFFICIENTS OF DIFFERENTLY PROCESSED POULTRY AND FISH OFFAL MEALS FOR AFRICAN CATFISH *Clarias gariepinus* (Burchell, 1822) JUVENILES

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ABSTRACT

Wastes from poultry and fish processing plants whose disposal presently raises a major environmental concern may be a source of animal protein in fish diet, if properly processed. This study was carried out to determine the apparent digestibility coefficients (ADCs) of nutrients in differently processed poultry and fish offal for *Clarias gariepinus*. A reference diet (R) was formulated to contain 40% crude protein. Test diets contained 70% reference diets and 30% of test ingredients, with chromic oxide as the inert marker. The test diets were poultry offal paste with wheat offal as carrier (P1), oven-dried poultry offal (P2), autoclaved poultry offal (P3), autoclaved fish offal (F1), oven-dried fish offal (F2) and fish offal paste with wheat offal (F3). A total of 315 African catfish, *Clarias gariepinus* juveniles (average weight; 5.50±0.50 g) were randomly distributed into 21 plastic tanks of dimension 0.42m x 0.29 m x 0.25m at 15 fish per tank. Diets R, P1, P2, P3, F1, F2 and F3 were fed to triplicate groups of fish twice daily at 5% body weight for 8 weeks and excess feed siphoned out 30 minutes after each feeding. Faecal collection was done 8 hours after every feeding and pooled for each treatment for chemical analysis. Apparent Digestibility Coefficients of nutrients varied significantly across treatments ($p<0.05$). ADC of crude protein was highest in F3, fish offal paste/wheat offal (78.63%) and lowest in F1, Autoclaved fish offal (65.83%). ADC lipid was highest in F3 (81.37%) followed by F2, oven dried fish offal (80.54%) and F1 (73.94%). ADC of phosphorus was highest in F2 (97.27%) followed by F3 (86.71%) and least in F1 (81.27%). The result of this study reveals that fish offal subjected to oven drying and the one blended with wheat offal showed high nutrient digestibility and therefore, can be utilized as protein source in the diets of *Clarias gariepinus*.

Key Words: *Clarias gariepinus,* Poultry Offal, Fish Offal, Processing, Digestibility

INTRODUCTION

Nutrition plays a critical role in intensive aquaculture as it influences not only the production cost but also fish growth, health and waste production (Gatlin, 2002). For profitability and success in fish farming, ingredients for feed production must be readily available and cheap to produce diets that are cost-effective. Similarly, the bioavailability of nutrients in ingredients is very crucial for successful fish nutrition. The conventional feed ingredients for fish are mainly from plant and animal products especially by-products of processing plants. Some of these products are also used as human food (SRAC, 2010). Feed is the single most expensive factor in aquaculture production and the protein component of fish diet constitutes the highest cost, this is because the fishmeal that supplies the bulk of the protein is very expensive (Aniebo *et al.*, 2009). The proportion of protein in fish diets is higher than those of other cultured animals, thus making feeds very exorbitant (Aniebo *et al.*, 2009). Depending on the stage of growth, studies have shown that the African catfish requires between 35-50% crude protein in their diet, with resultant cost implication (Wilson and Moreau, 1996; Adebayo and Quadri, 2005). For sustainable and profitable fish farming, there is therefore a pressing need to reduce feed cost through the use of locally available, cheap and accessible materials.

Wastes generated from poultry and fish processing are potential protein source for cultured fish. In Nigeria, there is a rapid expansion of small and medium-scale poultry farms with huge amount of waste generation. Similarly, the fish processing industry generates wastes consisting of discarded parts (internal organs such as liver, heart, kidney, eggs, gills, and gonads, bone and sometimes head) which are not fit for human consumption. The huge quantity of wastes has caused some serious environmental havoc such as vectors for insects, vermin, bacteria, and viruses, which may result in water contamination (leaching of nutrients and pathogenic microorganisms) and air pollution (FAO, 2011). However, instead of being wasted and dumped, they can be utilized to produce fish feed and indirectly helps towards a greener environment.

The utilization will however require some form of processing, as feeding of fresh fish offal to fish was reported to cause mycobacteriosis (Francis-Floyd, 2011). The reduction or elimination of pathogens is mostly achieved through heat treatment (Sauli *et al*., 2005), as it is simple and easy to adopt among local farmers. They however do have the potential to damage useful nutrients if appropriate processing technique is not applied (Papadopoulos, 1989). It is also of utmost importance that the nutrients present in feedstuffs are completely available to the animal body. Otherwise, large portions of the nutrients are excreted in the faeces because of not being digested in the alimentary tract. Digestibility study is thus very important in the selection of feed ingredients for feed formation. It is described it as one of the most important aspects in evaluating the potentials, efficiency of animal feedstuffs and basic requirements for formulating fish diets (Allan et al., 2000; Cho and Kaushik, 1990).

This study is aimed at determining the nutrient digestibility of differently heat treated poultry and fish offal meals by *Clarias gariepinus.*

MATERIALS AND METHODS

PROCESSING OF OFFAL

Offal of fish and poultry were procured from processing plants in Ile-Ife, Osun State. The fish and poultry offal were divided into three portions each.

Autoclaved Fish and Poultry offal meals: A portion of fish offal and poultry offal were seperately autoclaved at 15 psi for 20 minutes and then oven dried at 70^oC for 24 hours, milled (Giri *et al.,* 2000) and designated as F1 and P1 respectively.

Oven-dried Fish and Poultry offal meals: A second portion of fish and poultry offal each were dried in hot air oven at 55^0C for 48 hours, milled (Giri *et al*., 2000) and designated as F2 and P2 respectively.

Offal in wheat meals: A third portion of fish and poultry offal were blended into paste (using an electric blender) and mixed with wheat offal at ratio 7:1 (Offal:Wheat), (slight modification of Makinde and Sonaiya, 2012) and oven dried at 50 ^0C for 48 hours, milled and designated as F3 and P3 respectively.

EXPERIMENTAL DIETS

A reference diet was formulated using Pearson square method to contain 40% crude protein (Table 1). Test ingredients for digestibility test were autoclaved fish offal (F1), autoclaved poultry offal (P1), oven-dried fish offal (F2), oven-dried poultry offal (P2), fish offal paste with wheat offal (F3) and poultry offal paste with wheat offal (P3). The test diets contained 70% reference diet and 30% of each of the test ingredients on a dry weight basis (Dong *et al.*, 2010; Luo *et al.*, 2009; Falaye *et al.*, 2014), with chromic oxide (Cr_2O_3) as inert marker (Cho and Slinger, 1979). Test ingredients were thoroughly mixed with other ingredients with cassava starch as binder. The mash was then pelletized with 2 mm die hand-driven pelletizer to form pellets. The diets were then sundried at atmospheric temperature and humidity for 2 days and packed into well-labeled air-tight plastic containers until ready to use.

Table 1: Feed Formulation for Reference and Experimental Diets (g/100g)

Ingredient	Reference Diet	Experimental Diet
Fish meal	8.70	6.13
Soybean meal	43.75	30.63
Groundnut cake	17.50	12.25
Maize	24.49	17.14
Vitamin premix	1.00	0.70
Dicalcium phosphate	1.00	0.70
Lysine	0.50	0.35
Cr_2O_3	0.50	0.35
Salt	0.50	0.35
Starch	1.00	0.70
Palm Oil	1.00	0.70
Test Ingredient	----	30
Total (g)	100	100

EXPERIMENTAL DESIGN AND PROCEDURE

The experiments were carried out in rectangular plastic tanks of 0.42 m x 0.29 m x 0.25 m with water volume maintained at 20 L in each. After a 7-day acclimatization to laboratory conditions, a total of 315 African catfish, *Clarias gariepinus* juveniles with an average weight (5.50±0.50 g) were randomly allocated into 21 experimental plastic tanks at the rate of 15 juveniles per tank.

Diets were fed to triplicate groups of fish twice daily, between 7.00 - 8.00 am and 4.00-5.00 pm at 5% body weight throughout the experiment. The ration was adjusted every two weeks when new mean weights of fish for the various experimental units were determined. Leftover (uneaten) feed in each tank was siphoned 30 minutes after feeding to avoid leftover feed contaminating the faeces. Faeces in each tank were gently siphoned out using siphoning hose of 2 mm diameter every 8 hours after feeding. The faeces were pooled for each treatment and dried.

CHEMICAL ANALYSIS

The mineral and proximate composition of different diets and fecal samples were done as described by A.O.A.C (2005). Chromic oxide contents were determined as described by Farukawa and Tsukahara (1966).

APPARENT DIGESTIBILITY COEFFICIENT (ADC)

The apparent digestibility coefficients (ADCs) of protein, lipid and phosphorus for test and reference diets were calculated as follows (Cho and Slinger, 1979)

$$ADC\ nutrient = 100 - 100\left(\frac{Cr_2O_3\ in\ diets}{Cr_2O_3 in\ feaces} \times \frac{Nutrient\ in\ feaces}{Nutrient\ in\ diets}\right)$$

Since the test ingredients substituted 30% of the reference diet, the ADC of the ingredients were calculated according to the following equation (De silva and Anderson, 1995):

$$\mathrm{ADCn} = \frac{\mathrm{ADCTD} - (\mathrm{Y\ x\ ADCRD})}{\mathrm{Z}}$$

ADCn: Apparent digestibility coefficient of nutrient in test ingredient, ADC_{TD}: Apparent digestibility coefficient in test diet and ADC_{RD}: Apparent digestibility coefficient in reference diet, Y is the reference diet proportion and Z is the test diet proportion.

STATISTICAL ANALYSIS

All data resulting from the experiment were subjected to one way analysis of variance (ANOVA) and subjected to Duncan's multiple range test at p<0.05. Analysis was carried out using SAS (statistical analysis software) system 2003 version.

RESULTS AND DISCUSSION

The proximate composition of test diets is presented in Table 2. The moisture in the diets ranged from 7.68% in F2 to 8.92% in P2. Ash content in diets varied significantly (p<0.05) ranging from 6.75% in P3 to 10.26% in F2. P3 and F3 groups with wheat offal meal had the least ash contents among the two. Crude fibre values were significantly lower (p<0.05) in the P2 and F2 groups, with the highest value recorded in P3 group. Similarly, crude protein was significantly lower in P2 and F2. The crude protein is significantly higher (p<0.05) in P1. The variation in proximate compositions of the test diets is attributed to the effect of the processing techniques used in this present study. Similar variations were reported for feedstuffs subjected to various heat treatments in Hueze *et al*, (2015).

Table 2: Proximate Composition of Experimental Diets

PARAMETER (%)	P1	P2	P3	F1	F2	F3	R	SEM
Moisture	8.64^{b}	8.92^{a}	7.82^{d}	8.29^{c}	7.68^{d}	8.76^{ab}	8.86^{a}	0.131
Ash	7.03^{f}	7.21^{e}	6.75^{g}	9.46^{b}	10.26^{a}	8.43^{c}	7.57^{d}	0.343
Crude Fibre	3.44^{bc}	2.73^{f}	3.70^{a}	3.57^{ab}	2.99^{e}	3.29^{cd}	3.12^{de}	0.089
Crude Protein	39.81^{a}	38.50^{d}	39.38^{b}	38.94^{c}	37.63^{e}	38.94^{c}	38.50^{d}	0.180
Lipid	21.53^{a}	21.84^{a}	17.86^{b}	14.34^{d}	16.41^{c}	13.50^{e}	7.31^{f}	1.296
NFE	19.55^{f}	20.80^{e}	24.49^{d}	25.40^{c}	25.03^{cd}	27.58^{b}	34.64^{a}	1.270

Means with the same superscripts along rows are not significantly different (P>0.05)

P1: Autoclaved Poultry offal diet, P2: Oven-dried Poultry offal diet, P3: Poultry offal paste + Wheat offal diet, F1: Autoclaved Fish offal diet, F2: Oven-dried Fish offal diet, F3: Fish offal paste + Wheat offal diet, R: Reference Diet

Result of the apparent digestibility coefficients (ADCs) of nutrients is presented in Table 3. Apparent digestibility of protein varied significantly as a result of heat treatment. Protein digestibility was significantly highest in P2 (83.36%) and least in P1 (56.06%). The apparent digestibility for crude protein in this study was lower than that reported by Hossain and Jauncey (1989), where observed apparent digestibility coefficient for crude protein of fish meal in carp was 88.9%. Also higher value of fish meal digestibility for *Labeo rohita* was also reported by Salim *et al.*, (2004). The ADCs for protein obtained in P2, F3 and F2 are in agreement with the range of protein digestibility values of 75 to 95% reported for freshwater fish fed selected diets (Koprucu and Ozdemir, 2005), while the ADCs of protein in F1, P3 and P1 are significantly lower than the range. It is important to note that protein content can be affected by heat treatment (Falaye *et al.,* 2014), and subsequently, the digestibility, as observed in F1 and P1 in this study. Part of the variation in the ADC of protein in different ingredients may also be explained by differences in the chemical composition resulting from processing techniques used for various feed ingredients (Koprucu and Ozdemir, 2005; Watson, 2006). Excessive heat as demonstrated in autoclaved meals denatures protein and thus negatively affects digestibility as affirmed by Falaye *et al.* (2014).

The apparent crude fat digestibility coefficients varied significantly ($p<0.05$) across treatments, with the highest recorded also in P3 (96.30%) followed by P1 (95.37%), P2 (91.74%) and the least in F1 (73.94%). The apparent digestibility coefficients of crude fat in F1, F2 and F3 in this study were lower than the values reported for fishmeal by NRC (1993), while the values of ADCs of lipid in P1, P2 and P3 are in line with reported values of 85-95% for fish meal. Crude fat digestibility in F2 and F3 groups are similar to 81.35% reported by Jalal *et al*., (2000). However, the apparent fat digestibility coefficients obtained in this study were higher than the 68% reported by Gaylord and Gatlin (1996).

The apparent phosphorus digestibility increased from 74.31% in P3, 81.27% in F1, 85.37% in P2 86.71% in F3, 97.27% in F2 to 99.57% in P1. Phosphorus is a very important factor in aquaculture. Its utilization in fed diets is critical in aquaculture effluent as it affects eutrophication (Falaye *et al.*, 2014).

Table 3: Apparent Digestibility Coefficients of Protein, Lipid and Phosphorus of Experimental Diets

PARAMETER (%)	P1	P2	P3	F1	F2	F3	SEM	P-VALUE
ADC Protein	56.06^{f}	83.36^{a}	57.09^{e}	65.83^{d}	76.96^{c}	78.63^{b}	3.20768	<0.0001
ADC Lipid	95.37^{b}	91.74^{c}	96.30^{a}	73.94^{f}	80.54^{e}	81.37^{d}	2.52817	<0.0001
ADC Phosphorus	99.57^{a}	85.37^{d}	74.31^{f}	81.27^{e}	97.27^{b}	86.71^{c}	2.63729	<0.0001

Means with the same superscripts along rows are not significantly different (P>0.05)

The result of this study reveals that autoclaving reduced crude protein digestibility as observed in P1 and F1, thus reducing the nutritive value of these ingredients. It can be concluded that oven-dried meals were better digested by *Clarias gariepinus* when ADC protein, lipid and phosphorus are considered and therefore should be explored in growth experiment for this species.

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