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Metabolizable energy and nutrient digestibility by turkey fed diets containing shrimp waste as a replacement for fish meal

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Abstract

The nutrition of turkeys involved the use of high crude protein corn-soybean based diets to achieve efficient feed conversion and improved growth. Unfortunately, the main protein sources used in turkey diets (fish meal and soybean meal) are very expensive hence there is a need to explore cheaper alternatives such as shrimp waste meal (SWM). It was hypothesized that Nigerian Indigenous turkeys could comfortably handle the residual chitin in SWM than the exotic breed due to their hardy nature. This study therefore seeks to investigate metabolizable energy values and apparent nutrient digestibility of diets containing varying inclusion of SWM (replacing fish meal) in the nutrition of growing turkeys. Four diets were formulated such that FM in the control diet (diet 1) was substituted by SWM at 150, 300 and 450g/kg (protein for protein) in diets 2, 3, and 4 respectively. Eighty-four weeks old mixed sex British United Turkeys (BUT) and 80 Nigerian Indigenous Turkeys (NIT) were allotted on weight equalization into four dietary treatments replicated four times with five turkeys per replicate in a 2 x4 factorial arrangement. The study was carried out in phases (starter, grower and finisher). Total faecal collection method was used for apparent, true nutrient digestibility and metabolizable energy values. Proximate composition of faecal samples was used to compute the apparent nutrient digestibility of dry matter, crude fibre, crude protein, ether extract and ash. At the starter phase, NIT recorded significant ($P<0.05$) higher values for ether extract (EE) and nitrogen free extract (NFE). Turkeys fed 450g/kg SWM recorded higher value ($P<0.05$) for EE. At the grower phase, higher ($P<0.05$) NFE recorded for NIT and higher Ash for BUT. Turkeys fed 300g/kg SWM recorded higher values ($P<0.05$) for DM and ash. At the finisher phase, only ash digestibility was significant ($P<0.05$) for breeds and levels of substitution. Higher value of AMEn was significantly ($P<0.05$) recorded for NIT as against BUT, the reverse was the case for TMEn. Substitution at 0g/kg had the higher values ($P<0.05$) for AME and TME and 150g/kg fed turkeys recorded the least value. At grower phase, BUT recorded higher ($P<0.05$) TMEn. At finisher phase, NIT recorded higher ($P<0.05$) AMEnbut lowerTMEn. Conclusively, the protein from FM can be safely substituted up to 150g/kg with the SWM protein without deleterious effects on nutrients and energy utilization of British United Turkeys (BUT) and Nigerian Indigenous Turkeys (NIT)

Keywords: British United Turkeys; Digestibility, Fish meal; metabolizable energy; Nigerian Indigenous Turkeys; Shrimp waste meal

Digestibilité des énergies et des nutriments métabolisables par des régimes alimentés par la Turquie contenant des déchets crevettes comme remplacement de la farine de poisson

Résumé

La nutrition des dindes impliquait l'utilisation de régimes alimentaires à base de protéines bruts élevés pour obtenir une conversion efficace des aliments et une croissance améliorée.

Malheureusement, les principales sources de protéines utilisées dans les régimes de Turquie (repas de poisson et farine de soja) sont donc nécessaires pour explorer des alternatives moins chères telles que le repas des déchets de crevette (RDC). Il a été hypothélé que les dindes indigènes nigérianes pouvaient gérer confortablement la chitine résiduelle dans RDC que la race exotique due à leur nature robuste. Cette étude cherche donc à enquêter sur les valeurs énergétiques métabolisables et à la digestibilité apparente en nutriments des régimes contenant une inclusion variable de RDC (remplaçant le repas de poisson) dans la nutrition des dindes en croissance. Quatre régimes ont été formulés de sorte que FM dans le régime de contrôle (régime alimentaire 1) a été substitué par RDC à 150, 300 et 450g / kg (protéine pour protéines) dans les régimes 2, 3 et 4 respectivement. Quatre-vingt-quatre semaines de sexe mixte dindes unies britanniques (DUB) et 80 dindes indigènes nigérian (DIN) ont été attribuées à une pondération de poids dans quatre traitements diététiques répliqués quatre fois avec cinq dindes par réplication dans une disposition 2 x4 factorielle. L'étude a été réalisée en phases (entrée, cultivateur et finisseur). La méthode de collecte totale de la fécule a été utilisée pour la digestibilité d'éléments nutritifs apparents et les valeurs d'énergie métabolisables. La composition proximité des échantillons fécaux a été utilisée pour calculer la digestibilité de nutriment apparente de matière sèche, fibre brute, protéine brute, extrait d'éther et cendres. À la phase de démarrage, DIN a enregistré des valeurs plus importantes significatives (P <0,05) pour l'extrait d'éther (EE) et l'extrait sans azote (ESA). Les dindes nourries 450g / kg RDC ont enregistré une valeur supérieure (p <0,05) pour EE. À la phase de producteurs, l'ESA plus élevée (P <0,05) enregistrée pour les cendres DIN et plus élevées, mais. Les dindes nourrissent 300g / kg RDC ont enregistré des valeurs plus élevées (p <0,05) pour DM et Ash. À la phase de finition, seule la digestibilité des cendres était significative (p <0,05) pour des races et des niveaux de substitution. Une valeur plus élevée d'AMEn était significativement (p <0,05) enregistrée pour DIN comme contre, mais l'inverse était le cas pour TMEn. La substitution à 0g / kg avait les valeurs plus élevées (P <0,05) pour les dindes AME et TME et de 150 g / kg ont enregistré la moindre valeur. En phase de producteurs, mais enregistré plus haut (p <0,05) tmen. À la phase de finition, DIN a enregistré une hausse (p <0,05) AgenbutLowertmen. En conclusion, la protéine de FM peut être substituée en toute sécurité à 150 g / kg avec la protéine RDC sans effets négratoires sur les nutriments et l'utilisation d'énergie des dindes unies britanniques (DUB) et des dindes indigènes nigériannes (DIN)

Mots-clés: Dindes unies britannique; Digestibilité, repas de poisson; énergie métabolisable; Dindes indigènes nigérian; Repas déchets de crevettes

Introduction

Turkey, one of the biggest species of poultry is now widely consumed in Nigeria. Turkey production is becoming more popular especially during Christmas and New Year as gift and this has caused an increase in the demand for turkey poults. Recently, the government of Nigeria banned the importation of turkey poults and as a result the demand for the Nigerian indigenous turkeys (NIT) has gone up greatly. The NIT are now being raised on a large scale, intensively to meet the demand during the festive periods. The production of turkeys involves the use of high-quality source(s) of protein to facilitate rapid growth. Fish meal (FM) is the main conventional source of animal protein in the diets of turkeys. However, high cost of this ingredient necessitates the need for search for products or by-products that can substitute for FM is on-going. Shrimp waste product from the shrimp processing industries has the potential of being an alternative protein source for poultry. The shrimp industry in Nigeria is mainly export oriented. As these shrimps are processed for export, considerable volumes of wastes are generated. These wastes constitute a serious environmental hazard through their decomposition. Instead of allowing these wastes to become an environmental hazard, they can be processed into high nutritional animal protein replacing wholly or partially FM in the diet of poultry. These wastes are readily available at a relatively cheaper price compared to FM. Yugandhar *et al.* (2017) reported that shrimp head alone represents 35-45% of the total shrimp production. This implies that shrimp waste is as much as shrimp production. Shrimp waste meal (SWM)contains chitin which is an N-acetylated glucosamine polysaccharide that forms part of the protein complex and is considered to have low digestibility (Rahman *et al.,*2016). It is well established fact that not all ingested nutrients in feedstuff are digested and absorbed by chickens. Digestion trials are used to determine the proportion of the nutrients in a feed or diet that can be absorbed from the gastro intestinal tract (GIT). Nutrient utilization is the degree to which an ingested nutrient from a particular source is absorbed in a form that can be utilized in metabolism by the animal (Ammerman *et al*., 1995). Bioavailability encompasses the sum of impacts that may reduce or promote the metabolic utilization of a nutrient. In general, poorly digested feed nutrients are less available to birds and more available to incompatible gut microflora and pathogens. Poor feed digestibility can be due to several anti-nutritional factors in feed ingredients. The requirements of the birds and digestibility of the ingredients are necessary to maximize the efficiency of production and diet formulation. It is not sufficient to make recommendation on usefulness of a feedstuff based on studies on the effect of inclusion of the product on growth performance or on proximate analysis of the feedstuff. This is because neither the growth performance of animal's response to feeding graded levels of feedstuffs nor the total content of nutrients in the feedstuff answers all the questions regarding usefulness of the particular feedstuff (Adeola and Olukosi, 2008). There are many important reasons for the determination of the ME values of ingredients used in formulating diets for poultry. Increase in efficiency of nutrient utilization and a consequent reduction in nutrient excretion to minimize environmental impact require the determination of nutrient and energy utilization values for feed ingredients used in diet formulation. According to Sibbald (1980) the relationship between energy requirement and intake is the cornerstone of practical diet formulation. Apparent metabolizable energy is one of the most practical and useful indicators of dietary energy available from ingredients (Agunbiade *et al*., 1996). It is opined that NIT (though smaller in size) should be able to utilize shrimp waste meal-based diets better than their exotic counterparts because of their naturally hardy nature.

Materials and methods

Study area

The experiment was carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), Abeokuta, Ogun-State, Nigeria. The farm is located in the Tropical rainforest vegetation zone of South-Western Nigeria on latitude $7^0$10N and longitude $3^0$2E. The prevailing climate is tropical humid with an average annual rainfall of 1037mm and a mean ambient temperature of about 34.7^{0}C. Humidity of the experimental location is lowest (37%-85%) (Federal University of Abeokuta Meteorological Station)

Collection and processing of shrimp waste

Fresh shrimp waste was collected from a shrimp processing industry in Lagos, south-west Nigeria and was immediately sun dried (till constant moisture of 10-11%). The sun-drying was carried out by spreading the shrimp waste thinly on a clean concrete slab for three consecutive days during afternoons/evenings. The length of drying period was about 8hours each day. The dried shrimp waste was milled using a laboratory mill of 2 mm sieve and stored in air tight container and kept in a cool, dry place. Chitin in shrimp waste meal was determined on the acid detergent fibre (ADF) as organic residue according to the method described by Stelmock *et al.*(1985). The minerals were assayed at specific wavelengths using the Buck Scientific Atomic Absorption/Emission Spectrophotometer (Perkin Elmer Optima 4300DV ICP Spectrophotometer, Beaconsfield, UK) while phosphorus was determined using the corning colourimeter.

Experimental diets

Four diets were formulated such that SWM substituted FM protein for protein in the control diet at 0, 150, 300 and 450g/kg feed. The crude protein (g/kg) and metabolizable energy (MJ/kg) contents of the diets were balanced within the recommended range (NRC, 1994).

A total number of two-hundred-day old mixed sex turkey poults comprising of one hundred BUT and one hundred Nigerian indigenous turkeys (NIT) were obtained from a reputable hatchery. The two species of turkeys were brooded separately for a period of 28-day pre-experimental period. During brooding, normal temperature and humidity standard were maintained while recommended medication and vaccination were strictly adhered to. Pre-starter diet was fed while clean water was offered during the 28days pre-experimental period. At 28 days, eighty (80) turkeys were selected on weight equalization basis from each species and used for the experiment. Twenty turkeys from each species were placed on each dietary treatment replicated four times with five turkeys per replicate.

The experiment was arranged in a 2 by 4 factorial experiment made up of two factors (turkey strains and diets) and four levels of substitution of fish meal with shrimp waste meal (0, 150, 300 and 450g/kg). The turkeys were reared in deep litter housing system with dried wood shavings as the litter material. The turkeys were managed intensively with respective experimental diets and water given *ad libitum.* The experiment which lasted 18 weeks was divided into three phases, starter (5-10 weeks), grower (11-16 weeks) and finisher (17-22 weeks).

Metabolic study

Apparent excreta digestibility of dry matter, crude fibre, crude protein, ether extract, ash retention of the diets was measured at the end of the starter, grower and finisher phases of the experiments by total collection method (Bourdillon *et al*., 1990). One turkey per replicate was randomly selected and housed in clean and disinfected individual cages for a 3-day adaptation period, during which experimental diets and water were supplied *ad libitum*. The birds were fasted for a day to empty their digestive tract. The turkeys were given a known quantity of feed and faeces were collected daily for three consecutive days by means of clean trays placed under the cages. The collected samples were oven dried at 80°C, milled and stored in a cool dry place for subsequent analyses.

Proximate analysis and chemical composition

The representative samples of droppings, diets and test ingredients were taken for proximate analysis according to AOAC (1995) procedure. Dry matter (DM) was determined by drying at 80°C for 48 hours; ash was measured in a muffle furnace at

Table1 : Gross composition of experimental diets

	Pre-starter ration	Starter ration (4-8 weeks)				Grower ration (9-12 weeks)			
Shrimp waste substitution levels (g/kg)		**0**	**150**	**300**	**450**	**0**	**150**	**300**	**450**
Maize	430.00	465.00	465.00	465.00	465.00	564.00	564.00	564.00	564.00
Soybean meal	412.00	345.00	345.00	345.00	345.00	258.00	258.00	258.00	258.00
Shrimp waste meal	-	0.00	25.00	50.00	75.00	0.00	15.00	30.00	45.00
Fish meal (72%)	80.00	80.00	68.00	56.00	43.00	50.00	43.00	35.00	28.00
Wheat offal	-	60.00	47.00	34.00	22.00	62.00	54.00	47.00	39.00
Bone meal	45.00	33.00	33.00	33.00	33.00	32.00	32.00	32.00	32.00
Oyster shell	20.00	9.00	9.00	9.00	9.00	25.00	25.00	25.00	25.00
Vit./Min.Premix[a]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Salt	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lysine	1.00	-	-	-	-	0.50	0.50	0.50	0.50
Methionine	4.00	-	-	-	-	0.50	0.50	0.50	0.50
TOTAL	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**
Determined[b] analyses (g/kg)									
ME (MJ/Kg)	11.93	11.78	11.80	11.80	11.82	11.87	11.88	11.90	11.95
Crude protein	281.90	262.70	260.70	258.70	256.20	206.40	205.30	205.00	204.10
Crude fat	37.60	34.10	35.00	36.00	36.90	34.30	34.90	35.40	36.00
Crude fibre	30.00	36.30	36.60	36.80	37.10	37.30	37.90	38.10	38.80
Ash	83.00	99.80	100.00	101.30	109.30	87.70	92.70	100.00	105.00
Mineral profile (g/kg)									
Phosphorus	8.60	7.00	6.80	6.60	6.40	6.20	6.10	6.00	5.90
Calcium	21.60	14.10	13.90	13.60	13.30	18.70	18.60	18.40	18.20

Vit/min premix contained per kg of diet: Vit A 11500IU, Vit D_3 1600IU, Riboflavin 9.9mg, Biotin 0.25mg, Pantothenic acid 11.0mg, Vitamin K 3.0mg, Vit B_2 2.5mg, Vit B_6 0.3mg, VitB_{12} 8.0mg, Nicotinic acid 8.0mg, Iron 5.0mg, Manganese 10.mg, Zinc 4.5mg, Cobalt 0.02mg, Selenium 0.01mg
ME =Metabolizable Energy, MJ = Mega Joule

510^{0}C for 8 hours. Crude protein (6.25 N) in the samples was determined by micro kjedahl apparatus, oil (as ether extract) was extracted with petroleum ether (b. p. 40-60^{0}C) by the Soxhlet method (AOAC, 1995). Gross energy (GE) of excreta and the diets were determined using an adiabatic bomb calorimeter (Parr Instrument Company, Moline, IL, USA).

Apparent and true metabolizable energy

At the end of starter, grower and finisher phases, one turkey was randomly selected from each replicate and moved into a metabolic cage. The turkeys were fasted for 24 hours to empty their digestive tracts and a known quantity of feed was fed. Another group of turkeys were randomly selected, moved into the metabolic cage and fasted for 24 hours, after which water was given without feed to determine the endogenous losses. At the expiration of 24 hours, excreta were collected quantitatively from the two groups of turkeys and weighed, oven dried at 60^{0}C and weighed again. The samples of the excreta were pooled together, for each turkey, milled and assayed for gross energy. The experiment was arranged in a 2 by 4 factorial design made up of two factors (exotic and indigenous turkeys) and four levels of substitution of fish meal with shrimp waste meal (that is 0, 150, 300, 450g/kg). The data collected were fitted into the General Linear Model SAS (2000) for least square analyses of variance. Duncan Multiple Range Test was used to separate the means that differed significantly (Gomez and Gomez, 1984).

Results and discussion

Digestibility study

Main effects of breed and SWM substitution on nutrients utilization by starter, grower and finisher turkeys are presented in Table 2. Ether extract (EE) and nitrogen free extract (NFE) digestibility were significantly affected (P<0.05) by breed. The NIT had higher(P<0.05) values for both parameters.BUT had higher (P<0.05) value for crude protein retention than NIT. Levels of SWM substitution significantly (P<0.05) affect ether extract (EE) with the highest value recorded for 450 g/kg and lowest for 300 g/kg SWM fed turkeys. At grower phase, BUT recorded higher valuefor ash digestibility than Nigeria Indigenous Turkeys (NIT). The inverse was the case for NFE digestibility.British United Turkeys (BUT) retain more protein than NIT and the reverse was the case for digestibility of EE. Digestibility of DM and Ash, varied significantly with the levels of SWM inclusion.Substitution at 300 g/kg had higher values for DM and Ash digestibility and lower values for these parameters were recorded at 150 g/kg level of SWM substitution. The regression analysis indicated that only the CP retention was significant (P<0.05). At finisher phase, BUT recorded significant (P<0.05) higher ash digestibility. Shrimp waste meal (SWM) substitution for FM at 300 g/kg had higher values for all the parameters while the lower values for these parameters were recorded for 150 g/kg SWM substitution.

Nutrient digestibility results indicated that as the turkeys matured, digestibility of dry matter (DM), crude protein (CP), ether extract (EE), ash and nitrogen free extract (NFE) increased with age. The values recorded for these parameters were higher in growing and finishing phases than starter for both BUT and NIT. This finding is in line with the report of Oduguwa *et al*. (2004) who reported that nutrients digestibility increased with the finisher broilers having higher values than the starters.

The results of crude fibre (CF) digestibility indicated that the starter has higher values than the grower and finisher does not agree with the report of Palander *et al.* (2005). These authors reported that apparent CF digestibility increased with age of turkeys from 4 to 12 weeks of age. The significant difference in digestibility of DM, EE and

NFE for NIT as against BUT at the starting phase could be as a result of the hardy nature of the NIT which enable them to ingest, digest and absorb at this tender age. However, the reverse was the case at the grower and finisher phases where the BUT had higher values of EE, NFE and CP. This could have contributed to the BUT having higher body weight gain and final live weight than the NIT. Similar observation was reported by Ojewola and Annah (2006) that high nitrogen and energy retention resulted into high body weight gain in broiler experiment. The non-significant effects recorded for level of SWM substitution on most of the nutrients at the starting phase of the experiments did not agree with the report of Ngoan *et al*. (2000) and Fanimo *et al*. (2004). These authors reported that SWM decreased significantly the digestibility of DM, CF, CF and ash. The results of their finding were attributed to high level of chitin in SWM and inferior amino acid balance. However, Khampaka *et al*. (2011) reported that SWM at or below 150 g/kg did not significantly affect DM, organic matter, ash, nitrogen retention and chitin digestibility. Chitin is known to form part of a protein complex and is considered to have low digestibility (Austin *et al.*, 1981). Castro *et al.* (1989) and Karasov (1990) reported that chitin physically blocks the access of digestive enzymes to lipids and proteins, thus affecting the digestibility of these nutrients. The outcome of this study could be as a result of low level of substitution in the diets. It has been reported by Ramanchandran Nair *et al.* (1987) that at low levels chitin have a growth promoting effect by producing glucosamine during its digestion through chitinase enzyme secreted by intestinal bacteria. Similar observation had been documented by Spreen*et al*. (1984). The parameters that were significantly affected by the levels of SWM substitution in this study at the grower and finisher phases indicated that the substitution of SWM for FM at 300 g/kg had the highest values. This is another pointer that low level of chitin may have growth promoting effect. The generally high values obtained for EE and NFE digestibility are understandable since EE (crude fat and oil) and NFE (soluble starch and sugars) portions of the proximate composition of any feed are very highly digestible and pose no problem to monogastrics in terms of their ability to ingest, digest and absorb. Also, the high fat digestibility values recorded is an indication that all the dietary treatments were comparable and had enough supply of the essential fatty acids which in turn could bring about improvement in the general physical properties of the feed (Ojewola and Annah, 2006).

Interactive effect of breeds and SWM substitution on nutrients utilization by starter, grower and finisher turkeys (Table 3) showed that interaction was not significant (P>0.05) for CP retention and the digestibility of DM, EE, Ash, CF and NFE. However, the indigenous turkeys recorded higher values for digestibility of DM, EE and NFE at various levels of SWM substitution. At grower phase, digestibility of fat by NIT increased as the level of SWM increased until 450 g/kg level of substitution. This trend was observed for CP retention for BUT. At the finisher phase, the parameters measured were not significantly affected. However, NIT fed 300 g/kg of SWM in substitution for FM had the highest values for CP retention, digestibility of DM, EE and NFE.

Table 2: Main effects of shrimp waste meal substitution for fish meal and breed on nutrients utilization of turkeys

	Breeds				LEVELS OF SUBSTITUTION (G/KG)					P Value		
Parameters	Exotic	Indigenous	SEM	P-value	0	150	300	450	SEM	L	Q	C
STARTER PHASE												
DM	64.17	65.95	1.83	0.510	64.74	63.30	65.28	66.91	2.58	0.309	0.159	0.441
CP	64.57	57.61	3.57	0.205	61.52	54.33	60.53	67.98	5.04	0.564	0.109	0.296
EE	66.29^{b}	75.88^{a}	2.46	0.025	68.16^{c}	74.82^{b}	64.12^{d}	77.25^{a}	3.48	0.024	0.409	0.661
CF	69.35	69.05	0.05	0.719	69.04	68.65	69.88	69.23	0.07	0.931	0.932	0.024
ASH	72.34	71.25	0.05	0.180	71.27	71.65	71.65	72.61	0.07	0.495	0.392	0.758
NFE	78.87^{b}	88.36^{a}	1.96	0.009	84.26	84.19	84.21	81.81	2.77	0.015	0.744	0.422
GROWER PHASE												
DM	73.49	73.97	1.07	0.758	71.64^{c}	70.28^{c}	78.13^{a}	74.86^{b}	1.51	0.264	0.562	0.409
CP	65.78	63.96	3.25	0.703	53.83	65.99	63.79	65.87	4.59	0.568	0.003	0.277
EE	81.63	84.11	1.76	0.348	81.04	81.52	86.19	82.74	2.49	0.197	0.943	0.774
CF	61.82	61.73	0.04	0.874	61.00	60.93	63.13	62.04	0.05	0.504	0.101	0.612
ASH	73.81^{a}	72.56^{b}	0.03	0.032	72.45^{c}	71.99^{d}	74.44^{a}	73.86^{b}	0.05	0.649	0.748	0.631
NFE	86.80^{b}	90.56^{a}	0.99	0.028	90.79	85.36	89.36	89.40	1.40	0.075	0.629	0.542
FINISHER PHASE												
DM	78.92	77.29	1.56	0.478	79.14	75.64	80.69	76.94	2.20	0.481	0.092	0.763
CP	89.23	88.37	0.08	0.466	89.66	87.45	90.03	88.04	1.11	0.397	0.089	0.723
EE	90.85	90.39	0.65	0.637	91.03	88.65	92.07	90.37	0.92	0.910	0.150	0.060
CF	61.82	61.73	0.37	0.874	61.00	60.93	63.13	62.04	0.52	0.504	0.101	0.631
ASH	73.81^{a}	72.56^{b}	0.34	0.032	72.45^{c}	71.99^{d}	74.44^{a}	73.86^{b}	0.05	0.649	0.748	0.820
NFE	72.46	70.26	2.04	0.467	72.64	68.29	74.73	69.78	2.89	0.467	0.090	0.612

DM=Dry matter, CP=Crude protein, EE=Ether extract, CF=Crude fibre, NFE=Nitrogen Free Extract. SEM, pooled standard error of means. ^{abcd}Means on the same row having different superscripts are significantly different when $P<0.05$

Table 3: Interactive effects of shrimp waste meal substitution for fish meal and breeds on nutrients utilization of turkeys

	Exotic				Indigenous					
	Level of substitution (g/kg)				Level of substitution (g/kg)					
Parameters	0	150	300	450	0	150	300	450	SEM	P Value
STARTER PHASE										
DM	62.58	60.39	63.91	69.81	66.91	66.22	66.66	64.02	3.66	0.436
CP	60.84	52.95	65.74	78.73	62.19	55.71	55.32	57.23	7.13	0.349
EE	59.32	68.63	61.30	75.91	77.00	81.01	66.94	78.59	4.92	0.465
CF	69.25	68.40	69.09	70.66	68.83	68.89	70.68	67.80	1.01	0.212
ASH	72.25	71.40	72.00	73.70	70.30	71.89	71.31	71.52	1.04	0.576
NFE	78.75	80.51	78.68	77.56	89.77	87.87	89.75	86.05	3.92	0.950
GROWER PHASE										
DM	72.73	68.05	78.49	74.68	70.56	72.51	77.76	75.04	2.13	0.486
CP	52.97	63.30	61.00	65.83	54.70	68.68	66.57	65.91	6.49	0.483
EE	79.85	76.92	85.79	83.97	82.23	86.13	86.59	81.50	3.52	0.451
CF	61.33	59.60	63.89	62.39	60.68	62.21	62.36	61.69	0.07	0.098
ASH	73.88	72.06	74.53	74.78	71.02	71.93	74.36	72.93	0.07	0.207
NFE	90.39	83.56	86.40	86.85	91.18	86.79	92.32	91.94	1.98	0.601
FINISHER PHASE										
DM	79.34	76.33	79.29	80.73	78.94	74.95	82.10	73.15	3.11	0.452
CP	89.82	87.76	89.31	90.01	89.51	87.15	90.75	86.07	1.58	0.438
EE	90.69	89.00	91.60	92.10	91.37	88.30	92.55	89.35	1.30	0.507
CF	61.33	59.66	63.89	62.39	60.68	62.21	62.36	61.69	0.07	0.098
ASH	73.88	72.06	74.53	74.78	71.02	71.93	74.36	72.93	0.07	0.207
NFE	72.94	69.27	72.86	74.77	72.33	67.32	76.59	64.80	4.08	0.448

DM=Dry matter, CP=Crude protein, EE=Ether extract, CF=Crude fibre, NFE=Nitrogen Free Extract.
SEM, pooled standard error of means

Metabolizable energy

At starter phase, breed effects were significant (P<0.05) on apparent and true metabolizable energy corrected for nitrogen (AMEn and TMEn). Higher value of AMEn was recorded for indigenous turkeys when compared with BUT, but the reverse was the case for TMEn. Shrimp waste meal substitution significantly (P<0.05) affect apparent and true metabolizable energy (AME and TME). Shrimp waste meal substitution at 0 g/kg had higher values for the measured parameters except for AMEn where 150 g/kg substitution recorded higher value. The results of the regression analysis indicated that only TMEn was only significantly (P<0.05) affected by the treatments. At grower phase, breeds effect was only significant (P<0.05) on TMEn with the exotic turkeys having higher value, reverse was the case for AMEn. Shrimp waste meal substitution significantly (P<0.05) affects AME, TME and TMEn. The higher value recorded for AME, TME and TMEn were at 300 g/kg, 450 g/kg and 0 g/kg levels of SWM substitution respectively. The results of the regression analysis indicated that only TMEn was significantly (P<0.05) affected by the treatments. The effects of breed were significant (P<0.05) on AMEn and TMEn at the finishing phase. BUT recorded higher value for AME and TMEn when compared with indigenous turkeys, the reverse was the case for AMEn. Shrimp waste meal substitution significantly (P<0.05) affects AMEn and TMEn with higher value for AMEn at 450 g/kg and TMEn at 0 g/kg level of SWM substitution. The results of the regression analysis show that linear and quadratic were significant (P<0.05) for AMEn and TMEn. The apparent metabolizable energy (AME) values recorded were lower than 15.5 MJ/Kg reported by Palander *et al*. (2005) in 8 weeks old turkeys. Robbins and Firman (2006) indicated that any methodology used to determine the ME will yield similar values. He revealed no difference between the pooled ME values of chickens and turkeys. This indicated that the value commonly found for chickens can be applied to turkeys. Dale and Fuller (1980) found a similar agreement in ME among roosters, broilers and turkeys. Higher values of AME recorded at the grower phase is in line with the result of Lala (2010) who reported higher values of AME for turkeys fed pasta waste-based diets. The observed trend can be assumed that the increase AME in growing turkeys is related to improvement in fat digestion. Many authors have reported that AME was positively correlated to fat digestion (Friesen *et al*., 1992; Steenfeldt *et al*., 1998, Steenfeldt and Heindl, 2000). Snulikowska and Mieczkowska (2000) reported that 62% of the increase in the AMEn values was due to better fat digestibility when broilers are fed wheat-based diet. Apparent metabolizable energy (AME) data for ingredients usually apply a correction for nitrogen (N). The correction for nitrogen removes the portion of food nitrogen that is deposited as protein tissue and not oxidized in the body to provide energy (Farrel, 1999). The AMEn and TMEn values recorded were higher than AME and TME. These results contradict the finding of Lala (2010) who reported lower values for AMEn and TMEn when turkeys were fed indomie and pasta waste-based diets. This is an indication that the turkeys were in positive nitrogen balance and the turkeys retained nitrogen. Which suggest that the energy supplied by SWM is well utilized compared with the control diet. The AMEn measurement allows feedstuffs to be compared on a similar basis (Scott and Pierce, 2001; Santos *et al*., 2002). The variation in the ME and MEn values of an ingredients is important when determining the quantity of the ingredient to be included in the diet (Lala, 2010). The AMEnrecorded at the finishing phase was lower than the value reported by Santos *et al*. (2002). They reported AMEn value of 14.54 MJ/kg for 16 weeks old tom turkeys fed corn-soybean diet. Higher AMEn recorded for NIT suggested better dietary energy utilization. The differences in response of starter, grower and finisher turkeys in terms of metabolizable energy values following dietary FM replacement with SWM might be as a result of age differences. According to Sulistiyanto *et al*. (1999) utilization of energy-giving feedstuffs in poultry was age dependent. In like manner, Batal and Parsons (2002) also reported that younger birds showed increased nutrient utilization than older birds. The values recorded for apparent and true metabolizable energy at the starter phase were higher than other phases.

The interactive effects of breed and SWM substitution were not significant (P>0.05) on the parameters measured. Values for AME at 0 g/kg level of SWM substitution were highest for both exotic and indigenous turkeys. Interactive effects of shrimp waste meal substitution and breeds on apparent and true metabolizable energy by growing turkeys were not significant (P>0.05) on the parameters. The higher TMEn value for BUT and lower value for NIT is noteworthy.

Table 4: Main effects of shrimp waste meal substitution for fish meal and breed on metabolizable energy of turkeys

STARTER PHASE												
	Breeds				LEVELS OF SUBSTITUTION (G/KG)					P Value		
Parameters	Exotic	Indigenous	SEM	P-value	0	150	300	450	SEM	L	Q	C
AME (MJ/KG)	11.76	11.82	0.12	0.695	12.56^{a}	1.96^{c}	11.70^{b}	11.94^{b}	0.16	0.855	0.150	0.687
AMEn (MJ/KG)	12.56^{b}	16.65^{a}	0.97	0.017	14.21	16.13	14.98	13.02	1.37	0.052	0.420	0.476
TME (MJ/KG)	13.69	13.69	0.00	0.882	14.46^{a}	12.96^{c}	13.54^{b}	13.79^{b}	0.00	0.596	0.100	0.531
TMEn (MJ/KG)	15.52^{a}	12.03^{b}	0.39	0.000	14.45	13.10	13.49	14.04	0.55	0.000	0.701	0.203
GROWER PHASE												
AME (MJ/KG)	12.74	12.76	0.53	0.805	12.98^{b}	11.72^{c}	13.63^{a}	12.67^{b}	0.07	0.747	0.573	0.116
AMEn (MJ/KG)	13.43	15.41	0.98	0.193	14.80	15.18	13.87	13.84	1.39	0.329	0.674	0.232
TME (MJ/KG)	14.06	14.06	0.00	0.217	14.34^{b}	13.21^{c}	14.71^{b}	13.96^{a}	0.00	0.890	0.753	0.077
TMEn (MJ/KG)	14.75^{a}	9.80^{b}	0.17	0.000	12.67^{a}	11.58^{b}	12.95^{a}	11.90^{b}	0.24	0.000	0.867	0.077
FINISHER PHASE												
AME (MJ/KG)	12.02	11.86	0.08	0.193	11.99	11.83	12.06	11.88	0.11	0.198	0.162	0.585
AMEn (MJ/KG)	12.31^{b}	12.60^{a}	0.07	0.026	12.16^{b}	12.33^{b}	12.64^{a}	12.68^{a}	0.11	0.010	0.324	0.297
TME (MJ/KG)	13.00	13.00	0.00	0.434	13.02	13.00	12.98	13.02	0.00	0.727	0.647	0.415
TMEn (MJ/KG)	14.13^{a}	9.24^{b}	0.29	0.000	12.04^{a}	10.98^{d}	11.85^{c}	11.87^{b}	0.42	0.000	0.518	0.111

AME, apparent metabolizable energy; AMEn, apparent metabolizable energy corrected for nitrogen; TME, true metabolizable energy; TMEn, true metabolizable energy corrected for nitrogen. SEM, pooled standard error of means. ^{abcd}Means on the same row having different superscripts are significantly different when $P<0.05$

Table 5: Interactive effects of breed and shrimp waste meal substitution on energy utilization by turkeys

	Exotic				Indigenous					
	Levelofsubstitution (g/kg)				Levelofsubstitution (g/kg)					
Parameters	0	150	300	450	0	150	300	450	SEM	P Value
STARTER PHASE										
AME (MJ/Kg)	12.44	10.80	11.61	12.17	12.67	11.13	11.78	11.71	0.23	0.370
AMEn (MJ/Kg)	12.47	15.00	11.99	10.61	15.96	17.25	17.97	15.43	1.94	0.793
TME (MJ/Kg)	14.46	12.96	13.54	13.79	14.46	12.96	13.54	13.79	0.00	0.471
TMEn (MJ/Kg)	15.65	15.01	15.20	16.21	13.25	11.20	11.78	11.87	0.78	0.656
GROWER PHASE										
AME (MJ/Kg)	13.03	11.61	13.65	12.67	12.93	11.83	13.61	12.66	0.11	0.483
AMEn (MJ/Kg)	13.38	14.15	11.97	14.23	16.223	16.20	15.77	13.45	1.97	0.690
TME (MJ/Kg)	14.34	13.21	14.71	13.96	14.34	13.21	14.72	13.96	0.00	0.634
TMEn (MJ/Kg)	15.15	14.27	15.64	13.95	10.19	8.89	10.27	9.86	0.33	0.256
FINISHER PHASE										
AME (MJ/Kg)	12.05	11.90	12.01	12.11	11.93	11.76	12.10	11.65	0.16	0.437
AMEn (MJ/Kg)	11.90	12.24	12.57	12.54	12.43	12.42	12.71	12.83	0.15	0.586
TME (MJ/Kg)	13.02	13.00	12.98	13.02	13.02	13.00	12.99	13.02	0.00	0.971
TMEn (MJ/Kg)	14.19	13.50	14.50	14.32	9.89	8.45	9.20	9.43	0.59	0.850

AME, apparent metabolizable energy; AMEn, apparent metabolizable energy corrected for nitrogen; TME, true metabolizable energy; TMEn, true metabolizable energy corrected for nitrogen. SEM, pooled standard error of means.

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