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Original Research Article

Effect of replacing soybean meal with shrimp waste meal in the diets of growing turkeys on nutrient digestibility and metabolisable energy

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Abstract

Soybean meal (SBM), one of the main protein sources in turkey production is becoming expensive. Shrimp waste meal (SWM), a by-product of the shrimp industry is a good prospect as a cheaper alternative. It was hypothesised that Nigerian indigenous turkeys (NIT) should be able to digest and utilise SWM better than British United Turkeys (BUT) because of their hardy nature. A 56-day study was carried out to determine metabolisable energy and apparent nutrient digestibility of growing turkeys fed diets containing SWM. Four diets were formulated such that SBM in the control diet (diet 1) was substituted by SWM at 150, 300 and 450 g/kg (protein for protein) in diets 2, 3, and 4, respectively. Eighty (80) four-weeks-old male sex BUT and 80 NIT were allotted on weight equalisation into four dietary treatments replicated four times with five turkeys per replicate in a 2 × 4 factorial arrangement. The total faecal collection method was used for determining apparent and true nutrient digestibility and metabolisable energy values. The experiment was arranged in a completely randomised design and data collected were analysed using ANOVA with SAS package. At the starter phase, NIT recorded ($p < 0.05$) higher values for dry matter (DM), Ether extract (EE), nitrogen-free extract (NFE), Apparent metabolisable energy corrected for nitrogen (AMEn) but lower true metabolisable energy corrected for nitrogen (TMEn). Turkeys fed SWM recorded higher ($p < 0.05$) AMEn. At the grower phase, turkeys fed 300 g/kg SWM recorded higher ($p < 0.05$) values for CF and ash. Ash and CP digestibility values were higher ($p < 0.05$) in BUT ditto for TMEn. It was concluded that NIT could handle SWM better than BUT, however, only at the starter phase at 300 g/kg substitution for SBM.

Keywords: British United turkeys; Nigerian indigenous turkeys; nutrient digestibility, metabolisable energy; nitrogen; nitrogen-free extract; fibre; faeces

INTRODUCTION

Turkey is a large poultry that has the tendency of growing big within a short period of time under good management practices with quality feed and feeding. Over decades, turkey production has contributed immensely to the protein need of the human populace and economic growth. The ban placed on importation of poultry products by the federal government of Nigeria has caused an increase in the production of Nigerian indigenous turkeys (NIT). In order to attain market size within a short rearing period, turkey requires a high protein density diet that will support its fast growth.

The major source of plant protein in turkey production is soybean meal (SBM). The high cost of SBM has led to an increasing cost of turkey feeds with a resultant high cost of turkey meat. Researchers all over the world have conducted various studies in order to look for cheaper and readily available alternatives to conventional protein sources. Shrimp waste (SW) ranks high in this regard. It is a product of the shrimp processing industry which includes the head (cephalothorax) and shell (exoskeleton). According to Brito et al. (2020), shrimp waste meal has 61.2 % organic matter, 30.4% crude protein, 38.8% ash, and about 9980 kcal metabolisable energy (ME/kg). Apart from its usefulness as a protein source in poultry diets, its uses will reduce the need for the disposal of shrimp by-products and the environmental impact of shrimp farming. Furthermore, SW can be obtained from fishing ports in coastal regions throughout the year and at a low cost because of the abundant natural supply of shrimps with an annual production of 12,000 metric tons (Achoja, 2019).

The utilisation of nutrients by poultry is a function of the digestion of the feedstuffs. Digestion studies are used to assess the percentage of the nutrients in a feed that will be absorbed from the gastrointestinal tract (GIT). According to Atchade et al. (2019), nutrient utilisation is the degree to which an ingested nutrient from a particular source is absorbed in a form that can be processed in metabolism. For efficient production and diet formulation, the requirements of the birds and the digestibility of the ingredients are germane. The relationship between energy requirement and intake is the pillar of practical diet formulation (Atchade et al., 2019). According to Pezeshkian et al. (2022), apparent metabolisable energy is one of the most practical and useful indicators of dietary energy available from ingredients. It is hypothesised that NIT should be able to digest shrimp waste meal-based diets better than BUT because of their naturally hardy nature. Therefore, this study seeks to look at the effect of replacing SBM with SWM in the diets of turkeys on nutrient digestibility and metabolisable energy.

MATERIALS AND METHODS

Study area

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

Collection and processing of shrimp waste

Fresh shrimp waste (SW) was collected from a shrimp processing industry in Lagos, southwest Nigeria, and was immediately sun-dried (till constant moisture of 10–11%). The sun-drying was done by spreading the SW thinly on a clean concrete slab for three consecutive days during afternoons/evenings. The length of the drying period was about 8 hours each day. The dried SW was milled using a laboratory mill of 2 mm sieve and stored in an airtight-tight container and kept in a cool, dry place. Chitin in SWM 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 colorimeter.

Research policy

Animal Ethics Committee guidelines of the Federal University of Agriculture, Abeokuta (FUNAAB, 2014) were strictly adhered to throughout the duration of the experiment.

Experimental diets, management of animals and design

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

Two-hundred one-day-old male turkey poults comprising one hundred BUT and one hundred NIT were obtained from a reputable hatchery. The two strains were brooded on a deep litter separately for a period of 28 days pre-experimental period, during which a pre-starter diet was fed and clean water was offered *ad libitum*. At 28 days, eighty (80) turkeys were selected on weight equalisation basis from each strain and used for the experiment. Eighty (80) BUT were assigned to the four treatments at twenty birds each. The treatment groups were replicated four times with five birds per replicate. The same procedure was applied to NIT.

The experiment was arranged in a 2 by 4 factorial design made up of two factors, turkey strains (NIT and BUT) and diets (four levels of substitution, that is 0, 150, 300, and 450 g/kg). The turkeys were reared in a 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 56 days was divided into two phases, starter (29–56 days) and grower (57–84 days). The gross composition of the experimental diets is presented in Table 1.

Metabolic study

Apparent digestibility of dry matter, crude fibre, crude protein, ether extract, ash of the diets were measured at the end of the starter and grower phases by the 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 GIT. 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 proximate analysis of the representative samples of faeces, diets, and test ingredients were carried out according to the Association of Official Analytical Chemists (AOAC, 1995). Dry matter (DM) was determined by drying at 80 °C for 48 hours; ash was measured in a muffle furnace at 510 °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 °C) by the Soxhlet method (AOAC, 1995). The gross energy (GE) of excreta and the diets were determined using an adiabatic bomb calorimeter (Parr Instrument Company, Moline, IL, USA).

Table 1. Table1. Gross composition of experimental diets

Phases of growth	**Starter (29–56 days)**				**Grower (57–84days)**			
Shrimp waste substitution levels (g/kg)	**0**	**150**	**300**	**450**	**0**	**150**	**300**	**450**
Maize	442.00	442.00	442.00	442.00	563.00	563.00	563.00	563.00
Soybean meal	355.00	302.00	247.00	193.00	284.00	241.00	198.00	155.00
Shrimp waste meal	0.00	69.00	138.00	207.00	0.00	55.00	110.00	165.00
Fish meal (72%)	80.00	80.00	80.00	80.00	60.00	60.00	60.00	60.00
Palm oil	20.00	20.00	20.00	20.00	10.00	10.00	10.00	10.00
Wheat offal	50.00	34.00	20.00	5.00	40.00	28.00	16.00	4.00
Bone meal	30.00	30.00	30.00	30.00	27.00	27.00	27.00	27.00
Oyster shell	12.00	12.00	12.00	12.00	5.00	5.00	5.00	5.00
Vit./Min.Premix[a]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Salt	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Lysine	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Methionine	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
TOTAL	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**	**1000.00**
Determined values (g/kg)								
ME (MJ/kg)	11.59	11.70	11.79	11.89	12.39	12.47	12.54	12.62
Crude protein	275.80	271.50	269.30	266.50	232.40	230.20	228.10	225.90
Crude fat	41.80	37.90	38.30	39.70	36.30	36.90	37.40	36.50
Crude fibre	36.10	35.80	36.70	35.50	42.80	43.10	42.50	43.40
Mineral profile (g/kg)								
Phosphorus	6.90	7.30	7.10	7.60	5.60	5.40	5.10	5.70
Calcium	12.40	13.10	12.80	13.50	8.50	9.20	8.70	9.50

Vit/min premix contained per kg of diet: Vit A 11500 IU, Vit D_3 1600 IU, Riboflavin 9.9 mg, Biotin 0.25 mg, Pantothenic acid 11.0 mg, Vitamin K 3.0 mg, Vit B_2 2.5 mg, Vit B_6 0.3 mg, Vit B_{12} 8.0 mg, Nicotinic acid 8.0 mg, Iron 5.0 mg, Manganese 10.0 mg, Zinc 4.5 mg, Cobalt 0.02 mg, Selenium 0.01 mg.

Table 2. Main effects of shrimp waste meal substitution for soybean meal and breed on nutrients utilisation of turkeys

Parameters	Breeds		SEM	P-value	LEVELS OF SUBSTITUTION (g/kg)				SEM	P Value		
	BUT	NIT			0	150	300	450		L	Q	C
STARTER PHASE												
DM	63.07[b]	71.63[a]	0.02	0.009	67.44	67.18	68.80	65.98	0.02	0.010	0.711	0.462
CP	81.47	81.06	0.01	0.790	81.90	81.15	82.03	79.93	0.01	0.495	0.418	0.798
EE	87.00[b]	90.09[a]	0.01	0.009	89.38	88.08	88.98	87.78	0.01	0.048	0.764	0.921
CF	69.35	69.05	0.01	0.686	69.04	68.65	69.88	69.88	0.01	0.931	0.932	0.024
ASH	72.34	71.25	0.01	0.180	71.27	71.65	71.65	72.61	0.01	0.495	0.392	0.758
NFE	45.65[b]	60.65[a]	0.03	0.003	52.21	55.33	55.33	51.63	0.04	0.745	0.745	0.247
GROWER PHASE												
DM	76.84	72.35	0.03	0.253	75.63	75.16	72.68	74.92	0.04	0.227	0.833	0.796
CP	88.47[a]	78.65[b]	0.02	0.006	85.63	84.08	81.90	82.61	0.03	0.001	0.021	0.981
EE	90.58	89.35	0.01	0.431	90.50	90.19	90.15	90.15	0.01	0.376	0.550	0.930
CF	61.82	61.73	0.00	0.874	61.00[c]	60.93[d]	63.13[a]	62.04[b]	0.01	0.504	0.101	0.612
ASH	73.81[a]	72.56[b]	0.00	0.032	72.45[c]	71.99[d]	74.44[a]	73.86[b]	0.00	0.649	0.748	0.631
NFE	67.71	64.89	0.03	0.564	66.86	66.86	64.17	67.30	0.05	0.580	0.365	0.739

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 soybean meal and breeds on nutrients utilisation of turkeys

Parameters	BUT Level of substitution (g/kg)				NIT Level of substitution (g/kg)				SEM	P Value
	0	150	300	450	0	150	300	450		
STARTER PHASE										
DM	64.11	60.94	65.17	62.05	70.77	73.42	72.42	69.91	0.04	0.833
CP	83.03	80.06	82.12	80.68	80.78	82.24	81.94	79.30	0.02	0.746
EE	88.41	85.11	87.73	86.74	90.35	91.05	90.17	88.81	0.01	0.402
CF	69.25	68.40	69.09	70.66	68.83	68.89	70.68	67.80	0.01	0.235
ASH	72.25	71.40	72.00	73.70	70.30	71.89	71.52	71.52	0.01	0.576
NFE	45.64	43.41	49.21	44.36	58.78	63.48	58.90	58.90	0.05	0.863
GROWER PHASE										
DM	72.39	79.48	79.69	75.80	78.87	70.84	65.67	74.04	0.05	0.292
CP	88.01	90.37	89.31	86.18	83.26	77.80	74.49	79.04	0.04	0.550
EE	88.91	91.76	91.62	90.02	92.08	88.62	86.41	90.28	0.02	0.276
CF	61.33	59.66	63.89	62.39	60.68	62.21	62.36	61.69	0.01	0.098
ASH	73.88	72.06	74.53	74.78	71.02	71.93	74.36	72.93	0.01	0.207
NFE	60.48	71.07	72.19	67.09	73.25	62.64	66.16	67.50	0.07	0.236

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

Apparent and true metabolisable energy

At the end of the starter and grower 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 was 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 °C, and weighed again. The samples of the excreta were pooled together, for each turkey, milled, and assayed for gross energy.

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

Digestibility study

The main effects of breed and SWM substitution on nutrient utilisation by starter and grower turkeys are presented in Table 2. At the starter phase, the NIT had higher ($p < 0.05$) values for dry matter (DM), ether extract (EE), and nitrogen-free extract (NFE) digestibility. The level of SWM substitution did not have a significant ($p > 0.05$) effect on the variables under study. The linear regression analysis indicated that DM, EE and NFE were significantly ($p < 0.05$) different. Cubic analysis was only significant for crude fibre (CF). Results at the grower phase indicated that BUT had higher ($p < 0.05$) values for ash and crude protein digestibility than NIT. The level of substitution of SWM at 300 g/kg had the highest values for CF and ash and the lowest values were recorded for turkeys fed 150 g/kg SWM. The results of regression analysis recorded for both linear and quadratic were significant ($p < 0.05$) for crude protein digestibility only.

The interaction between the breed and SWM substitution elicited no significant ($p > 0.05$) effect on nutrient utilisation of turkeys at both starter and grower phases (Table 3).

Metabolisable energy

Main effect of breed and levels of SWM substitution (Table 4). At the starter phase, a higher ($p < 0.05$) value of apparent metabolisable energy corrected for nitrogen (AMEn) was recorded for NIT whereas higher ($p < 0.05$) value for true metabolisable energy corrected for nitrogen (TMEn) was recorded for BUT. Turkeys fed diets containing SWM had significantly ($p < 0.05$) higher AMEn than turkeys fed 0 g/kg SWM.

At the grower phase, only TMEn was significant ($p < 0.05$) with BUT recorded higher value. Turkeys fed 0, 150, 300 g/kg SWM recorded significantly higher

Table 4. Main effects of shrimp waste meal substitution for soybean meal and breed on metabolisable energy of turkeys

STARTER PHASE												
	Breeds		SEM	P-value	LEVELS OF SUBSTITUTION (g/kg)				SEM	P Value		
Parameters	BUT	NIT			0	150	300	450		L	Q	C
AME (MJ/kg)	15.35	15.71	0.09	0.060	15.53	15.52	15.61	15.45	0.13	0.024	0.560	0.818
AMEn (MJ/kg)	6.68^{b}	8.42^{a}	0.21	0.003	5.46^{b}	7.90^{a}	8.09^{a}	7.77^{a}	0.30	0.000	0.168	0.161
TME (MJ/kg)	17.17	17.17	0.00	0.420	17.15	17.17	17.19	17.17	0.00	0.127	0.411	0.495
TMEn (MJ/kg)	13.25^{a}	10.39^{b}	0.41	0.001	11.79	11.44	11.05	11.05	0.58	0.009	0.093	0.647
GROWER PHASE												
AME (MJ/kg)	15.50	15.23	0.13	0.175	15.43	15.41	15.26	15.34	0.19	0.124	0.850	0.735
AMEn (MJ/kg)	9.61	8.23	0.44	0.057	9.75	8.96	7.83	9.15	0.62	0.131	0.284	0.981
TME (MJ/kg)	16.65	16.65	0.00	0.657	16.66	16.68	16.64	16.62	0.00	0.122	0.422	0.865
TMEn (MJ/kg)	21.55^{a}	10.11^{b}	0.51	0.000	16.56^{a}	17.73^{a}	15.55^{ab}	13.48^{b}	0.72	0.000	0.051	0.065

AME = apparent metabolisable energy; AMEn = apparent metabolisable energy corrected for nitrogen; TME = true metabolisable energy; TMEn = true metabolisable energy corrected for nitrogen; SEM = pooled standard error of means; ^{ab}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 utilisation by turkeys

STARTER PHASE										
	BUT				NIT					
Parameters	Level of substitution (g/kg)				Level of substitution (g/kg)				SEM	P Value
	0	150	300	450	0	150	300	450		
AME (MJ/kg)	15.39	15.23	15.46	15.31	15.67	15.81	15.76	15.60	0.18	0.799
AMEn (MJ/kg)	6.09	7.07	7.22	6.63	6.82	8.73	8.96	9.18	0.42	0.181
TME (MJ/kg)	17.15	17.17	17.19	17.17	17.15	17.17	17.19	17.17	0.00	0.238
TMEn (MJ/kg)	14.64	12.26	14.62	11.46	8.94	10.63	11.37	10.64	0.82	0.072
GROWER PHASE										
AME (MJ/kg)	15.30	15.66	15.63	15.41	15.57	15.17	14.89	15.27	0.26	0.312
AMEn (MJ/kg)	8.23^{c}	10.22^{b}	10.20^{b}	9.80^{b}	11.28^{a}	7.70^{c}	5.46^{d}	8.50^{c}	0.88	0.013
TME (MJ/kg)	16.66	16.68	16.64	16.62	16.66	16.68	16.64	16.62	0.00	0.760
TMEn (MJ/kg)	20.50^{c}	24.66^{a}	22.05^{b}	18.99^{d}	12.62^{e}	10.80^{f}	9.05^{g}	7.97^{g}	1.02	0.003

AME = apparent metabolisable energy; AMEn = apparent metabolisable energy corrected for nitrogen; TME = true metabolisable energy; TMEn = true metabolisable energy corrected for nitrogen; SEM = pooled standard error of means; ^{abcdefg}Means on the same row having different superscripts are significantly different when $p < 0.05$

TMEn values than birds fed 450 g/kg SWM. Regression analysis results show that linear value was significant ($p < 0.05$) only on TMEn. The interactive effect shows that NIT fed 0 g/kg had a highest ($p < 0.05$) value for AMEn whereas BUT fed 150 g/kg had the highest value for TMEn.

The interaction effects of breed and SWM substitution on energy utilisation for turkeys at the starter and grower phases are presented in Table 5. All the measured variables show no significant ($p > 0.005$) difference for all treatment groups at the starter phase. However, significant ($p < 0.05$) differences were recorded for AMEn and TMEn at the grower phase. Overall NIT fed control (0 g/kg) had the highest value for AMEn whereas NIT fed 300 g/kg SWM had the least overall AMEn. British United Turkeys (BUT) fed varying levels of SWM had higher AMEn values when compared with NIT fed with similar levels of SWM. British United Turkeys (BUT) fed 150 g/kg SWM had the highest TMEn while the least TMEn values were recorded with NIT fed with 300 g/kg SWM. Overall BUT fed varying levels of SWM had higher TMEn values when compared with their NIT counterparts.

DISCUSSION

Significantly higher values recorded for DM, EE, and NFE at the starter phase for NIT could be a result of their hardy nature which enables them to tolerate and digest more DM and NFE than their BUT counterpart. Also, the NIT is a light-weight bird when compared to BUT as a result of which they can jump about thereby expending more energy on exercises. Ether extract (EE) is the fat and oil portion of the proximate composition of any feedstuff which is highly digestible by poultry. The non-significant difference obtained for the variables measured for the level of SWM in replacement for SBM at the starter phase is an indication that the turkeys could effectively digest and utilise the nutrients in SWM up to 450 g/kg level of substitution. The reason for this could be a result of the quantity of feed the turkeys will take at this phase which will in turn depict the g/kg of SWM *vis à vis* chitin content that will be ingested. Ramachandran et al. (1987) reported that chitin at low levels has a growth-promoting influence by producing glucosamine during its digestion through the chitinase enzyme secreted by intestinal bacteria. The non-significant effects recorded at this phase for all the parameters measured in terms of substitution levels with SWM are in agreement with the findings of Khempaka et al. (2011). They reported that SWM at or below 150 g/kg did not significantly affect DM, organic matter, ash, nitrogen retention, and chitin digestibility. The results of this study and their report contradict the reports of Ngoan et al. (2000), Fanimo et al. (2004), and Khempaka et al. (2006). These authors observed a significant reduction in the digestibility of DM, CF, and ash when SWM was added to broiler chickens' diets. In addition, Brito et al. (2020) reported a reduction in DM digestibility when SWM was added at 200 g/kg in broiler diets. The slight mortality recorded was as a result of mild Salmonella infection which occurred at the rearing pen. However, the effect evened out since it was not localised to a specific treatment. It also occurred in the control birds.

At the grower phase, significantly higher values recorded for crude protein (CP) and ash by the BUT are understandable because they are genetically bred to attain the market size and weight in a short period of time. The birds need a high-density nutrient ration in order to express their genetic makeup. The ash content of the proximate composition of any feed is the depiction of the mineral level (Harris and Marshall, 2017). Adedokun and Adeola (2013) opined that the interaction between nutrients from diet influences energy availability as well as the imbalances between calcium and phosphorus affects food efficiency. The results of the level of SWM substitution for SBM have shown that the turkeys could digest the fibre fraction of the SWM up to 300 g/kg replacement. This finding is in tandem with the report of Palander et al. (2005) who stated that apparent CF digestibility increased with the age of turkeys. This is another pointer that a low level of chitin may have a growth-promoting effect. The proportion of SBM is reduced in the diets of grower turkeys as a result of increased energy sources in order to meet their energy requirement. This in turn reduced the SWM proportion in the diets.

Metabolisable energy value is a widely adopted measure of feed quality due to its practical applications in the preparation of poultry rations. It can be applied to various metabolic processes in the body.

The apparent metabolisable energy (AME) values recorded in this study for breeds and level of SWM substitution is at par with 15.5 MJ/kg reported by Palander et al. (2005) in 8 weeks old turkeys. According to the report of Robbins and Firman (2006), any methodology used to determine the ME will result in similar values. They reported no difference between the pooled ME values of chickens and turkeys, which means the value for chickens can be applied to turkeys. Abdollahi et al. (2021) reported that the concept of nitrogen correction for broilers has been challenged because modern broiler strains have comparable protein accretion. Authors like Steenfeldt and Heindl

(2000) reported that AME was positively correlated to fat digestion. According to the report of Smulikowska and Mieczkowska (2000), 62 % of the increase in the AMEn values could be due to better fat digestion in broiler chickens fed a wheat-based diet. According to Lopez and Leeson (2008), the correction for zero nitrogen retention was initially introduced to convert the AME values to nitrogen equilibrium and to eliminate the variation associated with the amount of nitrogen that is deposited as protein tissue and not oxidised in the body to provide energy.

The values of AMEn and TMEn recorded in this study is an indication that the turkeys were in positive nitrogen balance and retained nitrogen. This implies that the energy supplied by SWM is well utilised when compared with the diet without SWM (0 g/kg). The non-significant difference in the results of the interaction of breeds and SWM replacement levels at the starter phase could be attributed to the fact that the gastrointestinal tract (GIT) has not been fully developed at this early stage. Okoye et al. (2005) stated that as birds advance in age the gastrointestinal tract and absorption capacity become more efficient in carrying out digestive processes. In contrast, Batal and Parsons (2002) stated that younger birds showed increased nutrient utilisation than older birds. Although the rates of nutrient digestibility for both breeds were similar, utilisation of these nutrients may differ in term of meat accretion. The non-significant difference observed for AME and TME at the grower phase is in tandem with the findings of Oso et al. (2017) when growing BUT were fed diets supplemented with arginine. The observable trend in the results of the interaction of breeds and SWM replacement levels on AMEn and TMEn at the grower phase was an indication that BUT were able to utilise the energy component of the feed more efficiently than NIT. This could be attributed to their efficient feed utilisation which may be linked to their genetic make-up since they are genetically improved hybrid turkeys.

CONCLUSION AND RECOMMENDATION

The outcome of this research indicated that SWM showed prospects as an alternative to the expensive SBM in the diets of growing turkeys. It was concluded that NIT could handle SWM better than BUT only at the starter phase. Therefore, it is recommended that SWM in replacement of SBM should not exceed 300 g/kg in a composite ration of starter turkeys.

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CONFLICT OF INTEREST

The authors declared no conflicts of interest with respect to the research, authorship, and publication of this article.

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