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Nutritional value of tiger nut (*Cyperus esculentus*) offal on the performance of broiler chickens

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Abstract

Tiger nut offal is one of the common agro by products available in appreciable quantity all yaer round especially within the northern part of Nigeria. Its nutritional value is somewhat close to those of maize offal. Therefore, a 56 - day experiment was conducted to evaluate the response of broiler chickens fed graded levels of Tiger nut offal (TNO) as an energy source. Five iso-nitrogenous and iso-caloric diets tagged T1, T2, T3, T4 and T5, were compounded to contain 23 and 20% crude protein and 2800 and 3000 kcal/kg of metabolizable energy for starter and finisher phases, respectively. The TNO was included at 0, 5, 10, 15 and 20% levels in treatments, respectively such that T1 served as the control diet. A total of 200, one day old chicks were allotted to the 5 treatment groups, replicated 4 times and each replicate was allotted 10 birds. Parameters evaluated included growth rate, economics of production, blood parameters and carcass characteristics. The results showed that there was no significant variation (P>0.05) in the values obtained for growth parameters, economics of production, haematological parameters and serum biochemistry. However, there was significant difference (P<0.05) in dressed weight (1155.00 vs. 1350.00 vs. 1350.00 vs. 1525.00 and 1530.00 gbird^{-1}) and shanks weight (59.50 vs. 100.00 vs. 67.00 vs. 85.00 and 60.00 gbird^{-1}) which increased across the treatments as the levels of inclusion of TNO increased in the diets. Birds fed the diets 15 (T4) and 20% (T5) gave the best results compared to those fed the control and other levels. From the results of this experiment, poultry farmer can use up to 20% of TNO as a replacement for conventional energy source in the diet of broiler chickens without compromising the meat quality and health status of the birds.

Keywords: Broiler chickens, energy source, nutritional value, performance, tiger nut offal

Introduction

The use of unconventional feed stuffs as substitutes for grains and other feedstuffs have been suggested thus, the search for non-conventional feedstuffs has been the most active area of animal nutrition research in the tropical world (Ikani and Adesehinwa, 2000). The search for cheaper sources of animal protein brings poultry birds into focus. Yakubu *et al.* (2010) suggested that the quickest potential for bridging protein supply – demand gap lies in the production of highly prolific animals that are efficient converters of feed to flesh, have short generation interval such as poultry birds and the integration of the wide array of cheap and locally available non-conventional feedstuffs at our disposal into well-defined feeding systems to reduce cost. Tiger nut (*Cyperus esculentus*) is one of the underutilized crops of the family *Cyperaceae*, which produces rhizomes from the base and tubers that are somewhat spherical. According to Sanchez-Zapata *et al*. (2012), tiger nut is an edible perennial grass-like plant, native to the 'old world' which consists of Europe, Asia and Africa and is a lesser-known vegetable that produces sweet nut-like tubers known as 'earth almond'. It is often cultivated for its nutritive edible nuts and high content of soluble glucose of about 21% (Bamishaiye *et al.,* 2010). Nutritionally, the nut produces high quality oil of up to about 25.5% content and about 8% of protein. The nut is high in oil content and is valued for the nutritious starch content, dietary fibre and carbohydrates (Bibek, 2001). Tiger-nut is also an excellent source of some useful minerals such as iron and calcium which are essential for body growth and development (Oladele and Aina, 2007). They also contain other mineral elements such as phosphorus, potassium sodium, magnesium, zinc and traces of copper and vitamins E and C (Oladele and Aina, 2007). It was reported that tiger-nut is high in dietary fiber content, which could be effective in the treatment and prevention of many diseases including colon cancer, coronary heart diseases, obesity, diabetics and gastro intestinal disorders while its tubers are used as an aphrodisiac, carminative, diuretic and a stimulant (Aletor *et al.,* 1995). Tiger-nuts have been reported to be used in the treatment of flatulence, indigestion, diarrhoea and dysentery. In addition, tiger-nut has been demonstrated to contain higher essential amino acids than those proposed in the protein standard by the FAO/WHO in 1985 for satisfying adult needs (Belewu and Adedunmi, 2008). In spite of the numerous health benefits of tiger nut, its potentials and prospects as energy source for poultry and livestock production has not been delved into extensively (Oladele *et al*., 2010). It is against this backdrop that this study was carried out to investigate the prospect of feeding graded levels of tiger nut offal to the diets of broiler birds as a source of energy and the economic implications.

Materials and methods

Study area

The experiment was carried out at the Research and Teaching Farm of the Faculty of Agriculture, Nasarawa State University, Keffi, Shabu – Lafia Campus. It is located in the guinea savanna zone of North Central Nigeria. It is found in latitude 08^0 35'N and longitude 08^0 33' E. the mean monthly maximum and minimum temperatures are 35. 06^0C respectively while the mean monthly relative humidity is 74%. The rainfall is about 168. 90 mm (NIMET, 2008).

Laboratory analyses of TNO

Proximate analyses of TNO was carried out in the Laboratory of the Department of Animal Science, Faculty of Agriculture, Nasarawa State University, Keffi, Shabu-Lafia campus, using the procedure outlined by AOAC (2000). The result of the proximate analysis is presented in Table 3.

Feed description and experimental design

Five diets tagged T1, T2, T3, T4 and T5 were compounded to be isocaloric (2800 and 3000 kcal/kg, ME) and isonitrogenous (23 and 20 % crude protein) using tiger nut offal for starter and finisher birds, respectively. The TNO was included in the diets at 0, 5, 10, 15 and 20 % for the respective treatments in a Completely Randomized Design (CRD) for both starter and finisher phases; the diets were compounded such that they meet the nutrient requirements of those classes of birds as described by Oluyemi *et al.* (2002). The gross and energy composition of the experimental diets for starter and finisher birds are presented in Tables 2 and 3.

Experimental birds, management and design

A total of 200 day-old Anak 2000 broiler chicks were used for the experiment. They were randomly allocated to the diets at the rate of 10 birds per replicate and each treatment was replicated four times in a Completely Randomized Design. All experimental birds were given feed and water *ad – libitum* and standard management practices such as daily routines and vaccinations were strictly followed as described by Oluyemi and Robert (2002). The birds were housed in 20 deep litter pens with wood shavings spread on cemented floor to the depth of 2-5 cm. The wood shavings were raked weekly to ensure aeration and clean litter throughout the study. The total floor space of the pen was 24 m^2 and the space per bird was 0.12 m^2.

Vaccination and medication schedule

A planned programme of vaccination was followed strictly. The birds were vaccinated against Newcastle and Gumboro diseases. Procedure for vaccination was as recommended by the Jos ECWA Veterinary Services Department and the doses were administered according to the manufacturer's specification. Prophylactic measures were observed to prevent any possible outbreak of diseases.

Data collection

Growth parameters

Birds were batch weighed with digital weighing balance at the beginning of the experiment and weekly thereafter. Feeds were adjusted according to the new body weight changes. Other biological evaluations such as feed intake, body weight gain were recorded on replicate basis. Feed conversion ratio (FCR) was computed according to Mcdonald *et al*. (1995). Other parameters determined included final live weight, protein consumed and protein efficiency ratio.

Table 1: Gross composition of starter experimental diets

Ingredients	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**
Full fat Soybean	19.22	19.22	19.22	19.22	20.22
Groundnut cake	22.76	22.76	22.76	22.76	22.76
Rice bran	22.00	19.02	19.02	19.02	13.02
Tiger nut offal	0.00	5.00	10.00	15.00	20.00
Maize	30.52	19.00	25.00	19.00	19.00
**Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Bone ash	2.50	1.00	1.00	1.00	1.00
Palm oil	2.00	3.00	2.00	3.00	3.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculate energy and chemical composition					
*Energy (kcal/kg, ME)	2837.45	2802.10	2814.66	2802.10	28.33.10
Crude protein (%)	23.12	23.00	23.10	23.00	23.03
Crude fibre (%)	5.29	5.52	5.38	5.52	5.15
Ether extract (%)	12.04	12.65	11.73	12.65	12.11
Ash (%)	4.74	4.95	4.81	4.96	4.62
Calcium (%)	1.13	0.65	0.59	0.65	0.65
Phosphorus (%)	1.15	0.82	0.83	0.82	0.71
Lysine (%)	1.29	1.28	1.27	1.25	1.25
Methionine (%)	0.57	0.57	0.55	0.54	0.54

*Calculated from Pauzenga (1985), **The vitamin – mineral premix supplied the following per 100kg of diet: Vitamin A 15,000 I.U, Vitamin D_3 300,000 I.U., Vitamin E 3,000 I.U., Vitamin K 2.50mg, Thiamin, (B_1) 200mg, Riboflavin (B_2) 600mg, Pyridoxine (B_6) 600 mg, Niacin 40.0mg, Vitamin B_{12} 2mg, Pantothenic acid 10.0mg, Folic acid, 100mg, Biotin 8mg, Choline chloride 50g, Anti-oxidant 12.5g, Manganese 96g, Zinc 6g, Iron 24g, Copper 0.6g, Iodine 0.14g, Selenium 24mg, Cobalt 214mg.

Table 2: Gross composition of finisher experimental diets

Ingredients	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)
Full fat Soybean	20.00	20.00	20.00	20.00	20.00
Groundnut cake	15.00	15.00	15.50	15.50	16.50
Rice bran	16.00	16.00	12.50	7.00	1.50
Tiger nut offal	0.00	5.00	10.00	15.00	20.00
Maize	42.00	39.50	38.00	38.00	38.00
**Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Bone ash	3.00	1.00	1.00	1.00	1.00
Palm oil	3.00	2.50	2.50	2.50	2.00
Methionine	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculate energy and chemical composition					
*Energy (kcal/kg, ME)	3029.18	3013.98	3007.80	3027.91	3019.74
Crude protein (%)	20.17	20.37	20.22	20.15	20.32
Crude fibre (%)	4.63	4.86	4.69	4.35	4.03
Ether extract (%)	12.02	11.60	11.19	10.59	9.54
Ash (%)	3.90	4.08	3.94	3.64	3.36
Calcium (%)	1.36	0.61	0.61	0.60	0.57
Phosphorus (%)	1.12	0.78	0.71	0.62	0.52
Lysine (%)	1.18	1.78	1.15	1.13	1.12
Methionine (%)	0.55	0.55	0.53	0.52	0.51

*Calculated from Pauzenga (1985), **The vitamin – mineral premix supplied the following per 100kg of diet: Vitamin A 15,000 I.U, Vitamin D_3 300,000 I.U., Vitamin E 3,000 I.U., Vitamin K 2.50mg, Thiamin, (B_1) 200mg, Riboflavin (B_2) 600mg, Pyridoxine (B_6) 600mg, Niacin 40.0mg, Vitamin B_{12} 2mg, Pantothenic acid 10.0mg, Folic acid, 100mg, Biotin 8mg, Choline chloride 50g, Anti-oxidant 12.5g, Manganese 96g, Zinc 6g, Iron 24g, Copper 0.6g, Iodine 0.14g, Selenium 24mg, Cobalt 214mg.

Economics of production

Parameters such as cost of feed per unit weight gain, profit, cost of production, revenue and gross margin were determined.

Carcass characteristics

At the end of the 8th week of experimentation, carcass data was collected from four randomly selected birds per treatment group. The birds were fasted for 12h (but with access to water only) and individually weighed using a 5-kg scale with a precision of 0.005. The birds were starved to determine the actual live weight of the birds and reduce gut content thus, reducing the risk of contamination of the carcass during dressing without affecting meat quality. They were then slaughtered by severing the carotid arteries and jugular veins and blood drained under gravity; the carcasses were then divided into the following parts as described by Kleczek *et al.* (2007).

Head-The head was obtained by cutting off between the occipital condyl and the atlas.

Neck-This was obtained by cutting along the line joining the cephalic borders of the coracoids.

Shank-This was obtained by cutting off through the hock-joint (sesmoid).

Wing-The wing was obtained by cutting through the shoulder joint.

Thigh-This was obtained by cutting through the hip joint (from the pubic process, through the groin towards the back, and the along the backbone, starting from the anterior border of the pelvis).

Breast plate-It was obtained by a double cut through the cartilaginous junctures of the ribs, from the anterior border of the backbone towards the coracoids.

Back-This is referred to as the dorsal-lumbar quarter (the remaining part of the carcass). The relative fasted body weight (% of final live body weight) was obtained. The weight of the thigh, breast, and back were taken as the carcass weight, which was later expressed as percentage of the final live body weight. Similarly, the relative weights of the cut parts (head, neck, shank, wing, thigh, breast, and back) and the visceral organs (liver, heart, kidney, gizzard and small and large intestines), was determined using the formula (Mohammed *et al.,* 2008; Grosso *et al.,* 2009):

$$\text{Relative weight (cut part or organ)} = \frac{\text{Fresh weight of cut part or organ}}{\text{Final live body weight of bird}} \times 100$$

Haematological indices

At the end of the feeding trial of the finisher phase, blood samples **were** collected for the evaluation of the haematological indices. The bloods were collected into sample bottles containing 1mg of dipotassium salts of ethylene diamine tetra acetic acid (EDTA-K^2) to 1ml of blood. The haematological indices determined **were** packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC) and haemoglobin concentration. PCV **was** determined using wintrobes micro haematocrit method (Margi, 1997); haemoglobin concentration **was** determined by the Cyanomethaemoglobin method as outlined by Kelly (1979). The improved Neubarhaemocytometer method as described by Jain (1986) **was** used to estimate the red and white blood cells. Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) **were** computed according to Jain (1986).

Serum biochemical constituents

Another blood samples **were** collected in another separate sample bottles without anti-coagulant to allow clotting for serum biochemical analysis. Constituents such as protein, globulin, urea and triglyceride **were** analyzed using sigma kits while glucose **was** analyzed according to Schalm *et al.* (1975).

Statistical analysis

Data obtained were subjected to One Way Analysis of Variance (ANOVA). The separation of the means was effected using least significance difference method and tested at probability level of 5% as described by Steel and Torries (1980). Each experimental bird was randomly assigned to a test diet in a Completely Randomized Design (CRD). The following statistical mode was used: $Y_{ij} = \mu + T_{ij} + e_{ij}$ Where Y_{ij} = Individual observation, μ = Population mean, T_{ij} = Treatment error, e_{ij} = Random error.

Results and discussion

Proximate composition of TNO

The results of the proximate composition of TNO reveal that the test ingredient is rich in energy (2229.78 kcal/kg, ME) and carbohydrate (51.82%) but low in other nutrients such as crude protein (8.57%), crude fibre (5.96%), ash (4.43%) and NFE (45.86%). The relatively low moisture content (3.65%) of the TNO indicates that the material may have a high keeping quality over a long period of time without spoilage. In view of the high energy and carbohydrate values that are somewhat close to most cereal grains (Alu, 2015b), it suggests that TNO could conveniently replace other conventional energy feedingstuffs in the diets of broiler chickens.

Table 3: Proximate and energy composition of TNO

*Energy (kcal/kg, ME)	CP (%)	CF (%)	EE (%)	Ash (%)	CHO (%)	NFE (%)	Moisture (%)
2229.78	8.57	5.96	3.51	4.43	51.82	45.86	3.65

*Calculated from Pauzenga (1985)

Effect of graded levels of TNO on the growth performance of broiler chicks

The results of the effect of graded levels of TNO on the growth performance of broiler chicks are presented on Table 4. There was no significant variation (P>0.05) on all the parameters evaluated. However, numerical differences existed indicating an upward trend for final weight (960.00 vs. 992.00 vs. 975.00 vs. 1000.00 and 870.00 gbird^{-1}) and daily weight gain (31.00 vs. 32.50 vs. 31.25 vs. 32.10 and 27.50 gbird^{-1}) as the level of TNO inclusion increased from the control diet to T4 (15%). The mortality rates, 7.50 vs. 15.00 vs. 10.00 vs. 15.00 and 2.50% recorded for T1, T2, T3, T4 and T5 were due to other challenges such as health and mishaps as there was no nutritional disorder. The non-significant difference observed may be seen as an indication of the safety and adequacy of the test ingredient (Alu *et al.,* 2009). Birds would normally respond to bad diets almost immediately after consumption by having poor turnover of feed to flesh and more importantly, depressed feed intake. The values recorded in the present study for final body weight, daily weight gain and FCR were close to those previously reported by Agbabiaka *et al.* (2012), Agbabiaka *et al.* (2013), Kwadwo *et al.* (2014) and Agbabiaka *et al.* (2013).

Table 4: Effect of graded levels of TNO on growth performance of broiler chicks

Parameters	TREATMENTS						
	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	LOS
Initial weight (g/bird)	94.50	81.50	94.50	96.50	101.00	7.36	NS
Final weight (g/bird)	960.00	992.00	975.00	1000.00	870.00	20.77	NS
Feed intake (g/bird)	55.50	55.50	51.50	53.50	48.00	1.67	NS
Weight gain (g/bird)	31.00	32.50	31.25	32.10	27.50	0.68	NS
FCR	2.42	2.59	2.72	3.285	5.24	0.52	NS
Protein Intake (g/bird)	13.00	13.00	12.10	12.00	11.20	0.35	NS
PER	2.65	2.50	2.50	2.70	2.50	0.15	NS
Mortality (%)	7.50	15.00	10.00	15.00	2.50	2.11	NS

SEM= Standard error of mean, LOS= Level of Significance, NS= Not significantly different (P>0.05).

Effect of graded levels of TNO on the economics of production of broiler chicks

A similar trend was recorded for the economic implication (Table 5). There was no variation (P>0.05) on the parameters evaluated due to TNO inclusion across the treatment groups. However, there was a numerical reduction in the cost of production (465.50 vs. 466.50 vs. 433.00 vs. 427.40 and 406.00 <) for treatments T1 to T5, respectively, while that of profit (1933.00 vs. 1933.50 vs. 1092.50 vs. 1972.60 and 1994.00 <) increased as the level of TNO increased in the diets. The reduction in the cost of production and increase in profit are attributed to the fact that the test ingredient did not attract any monetary value as it is considered as a waste product (Adgizi *et al.,* 2013) after local drinks production.

Table 5: Economics of production of broiler chicks fed graded levels of TNO

Parameters	TREATMENTS						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	SEM	LOS
Feed cost/100kg (</kg)	17045.50	17039.10	16039.10	15189.10	15409.10	-	-
Feed cost/kg (</kg)	170.45	170.39	160.39	151.89	154.09	-	-
FC/WG (</kg)	3.50	5.45	4.50	3.50	3.50	1.91	NS
Cost of production (<)	465.50	466.50	433.0	427.40	406.0	9.71	NS
Profit (<)	1933.00	1933.50	1092.50	1972.60	1994.00	271.53	NS
Revenue (<)	74.50	78.50	75.50	77.50	66.15	1.71	NS
Gross margin (<)	390.95	388.00	357.50	349.50	340.00	8.77	NS

SEM= Standard error of mean, LOS= Level of Significance, NS= Not significantly different (P>0.05), FC/WG= Feed cost/ weight gain.

Effect of graded levels of TNO on the growth performance of broiler finisher chickens

Table 6 summarizes the effect of graded levels of TNO on growth parameters of broiler finisher chickens. Although there was no significant variation (P>0.05) in all the parameters, final weight, weight gain, protein intake and PER decreased numerically whereas feed intake and FCR increased with increased in the level of inclusion of TNO in the diets. The results obtained in the present study were superior to those earlier reported by Agbabiaka *et al.* (2012). The authors reported 1350 – 1720 $gbird^{-1}$, 18.57 – 39.52 $gbird^{-1}$ and 3.37 – 6.28 for final live weight, daily body weight gain and FCR, respectively. The superiority in the values recorded in the present may be attributed to the safety and high quality of the diets since the diets were balanced for all the nutrients required by this class of birds.

Table 6: Effect of graded levels of TNO on growth performance of broiler finisher chickens

Parameters	TREATMENTS						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	SEM	LOS
Initial weight (g/bird)	960.00	992.00	975.00	1000.00	870.00	20.77	NS
Final weight(g/bird)	1935.00	1635.00	1765.00	1865.00	1355.00	89.22	NS
Feed intake (g/bird)	112.00	82.50	102.50	132.50	82.50	10.33	NS
Weight gain (g/bird)	46.50	30.50	37.40	41.05	23.50	3.80	NS
FCR	2.00	2.50	3.00	3.00	5.50	0.57	NS
Protein Intake (g/bird)	22.50	16.550	20.90	26.50	16.50	2.07	NS
PER	2.00	2.00	1.90	1.50	1.50	0.20	NS
Mortality (%)	5.00	7.50	20.00	2.50	16.00	-	-

SEM= Standard error of mean, LOS= Level of Significance, NS= Not significantly different (P>0.05).

Effect of graded levels of TNO on the economics of production of broiler finisher chickens

The economics of production of broiler finisher birds fed TNO (Table 7) showed a similar trend as in the starter phase. There was no significant variation (P>0.05) due to TNO inclusion on the parameters evaluated. However, feed cost/weight gain (4.00 vs. 6.00 vs. 4.65 vs. 4.50 and <5.85/kg), profit (975.50 vs. 1886.00 vs. 1817.40 vs. 1702.75 and <1889.50) and gross margin (538.50 vs. 440.00 vs. 492.50 vs. 598.60 vs. and <455.00) increased numerically with increase in the level of TNO in the diets. Cost of production and revenue reduced with increase the level of TNO in the feed.

Table 7: Economics of production of broiler chickens fed graded levels of TNO

Parameters	TREATMENTS						
	T1 (0%)	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	SEM	LOS
Feed cost/100kg (< /kg)	191.05	181.30	178.13	178.60	178.08	-	-
Feed cost/kg (< /kg)	191.05	181.30	178.13	178.60	178.08	-	-
FC/WG (< /kg)	4.00	6.00	4.65	4.50	5.85	2.21	NS
Cost of production (<)	650.0	514.0	582.60	697.250	510.50	39.45	NS
Profit (<)	975.50	1886.00	1817.40	1702.75	1889.50	169.07	NS
Revenue (<)	115.00	73.50	90.00	98.650	55.50	9.16	NS
Gross margin (<)	538.50	440.00	492.50	598.60	455.00	33.25	NS

SEM= Standard error of mean, LOS= Level of Significance, NS= Not significantly different (P>0.05), FC/WG= Feed cost/ weight gain.

Effect of graded levels of TNO on carcass characteristics and visceral organs of broiler finisher chickens

The results of the effect of graded levels of TNO on carcass characteristics and visceral organs of broiler finisher chickens are presented in Table 8. The results show that there was no significant difference (P>0.05) in most of the parameters evaluated except for dressed weight (1155.00 vs. 1350.00 vs. 1350.00 vs. 1525.00 and 1530.00 gbird^{-1}) and shanks weight (59.50 vs. 100.00 vs. 67.00 vs. 85.00 and 60.00 gbird^{-1}) which significantly (P<0.05) increased across the treatment groups as the levels of inclusion of TNO increased in the diets. Birds fed the diets 15 (T4) and 20% (T5) gave the best results compared to those fed the control and other levels. There was numerical increase in the length of the small (169.75 vs. 185.00 vs. 176.50 vs. 202.50 and 181.50 cm bird^{-1}) and large intestines (12.00 vs. 13.50 vs. 13.50 vs. 14.50 and 13.75 cm bird^{-1}), weight of full gizzard (42.00 vs. 95.00 vs. 58.00 vs. 76.50 and 80.00 gbird^{-1}) and kidney (1.25 vs. 1.30 vs. 1.45 vs. 1.55 and 1.90 gbird^{-1}) as the level of TNO increased in the feeds. The results obtained in the present study confirms the earlier findings of Kwadwo *et al.* (2014) who fed broiler finisher chickens with alkaline-treated TNO and reported similar values for most of the carcass parameters. Alu (2015a) similar reported a non-significant variation in most of the carcass cuts and visceral organs of growing rabbits fed TNO based-diets.

Effect of graded levels of TNO on haematological indices of broiler finisher chickens

There was no significant variation (P>0.05) in the values for haematological indices (Table 9) evaluated. However, leukocytes, erythrocytes, PCV and haemoglobin increased numerically with increase in TNO in the feeds. The values recorded in the present study fell within the normal range for healthy broiler finisher chickens (Jain, 1993). The haematological indices are a reflection of health status of an animal and this implies that the test ingredient was not deleterious to the well-being of the birds.

Effect of graded levels of TNO on serum biochemical constituents of broiler finisher chickens

Similar to the haematological indices, there was no significant difference (P>0.05) in all the values recorded for serum biochemical constituents (Table 10) across the treatment groups due to TNO inclusion in the diets. Values recorded for total protein (36.00 vs. 48.00 vs. 39.50 vs. 43.50 and 41.50 g/dL), glucose (1.25 vs. 1.55 vs. 1.80 vs. 1.55 and 1.75 mmol/L), creatinine (37.50 vs. 37.50 vs. 39.50 vs. 44.00 and 42.50 mmol/L) and

Table 8: Effect of graded levels of TNO on the carcass characteristics of broiler finisher birds

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	LOS
Cut parts							
Bled weight (g/bird)	1420.00	1355.00	1355.00	1505.00	1355.00	55.21	NS
Dressed weight (g/bird)	1155.00[c]	1350.00[b]	1350.00[b]	1525.00[a]	1530.00[a]	48.30	***
ECW (g/bird)	1150.00	1000.00	1075.00	1150.00	1000.00	54.39	NS
Carcass length (cm/bird)	16.00	17.50	17.00	17.00	16.75	.2363	NS
Breast plate (g/bird)	375.00	275.00	325.00	400.00	300.00	21.15	NS
Drum stick (g/bird)	150.00	140.00	180.00	182.50	180.00	8.30	NS
Thigh (g/bird)	163.00	180.00	163.00	195.00	200.00	8.39	NS
Wings (g/bird)	126.50	425.00	112.00	126.50	160.00	57.21	NS
Head (g/bird)	35.00	38.00	37.00	39.00	43.00	1.51	NS
Neck (g/bird)	78.00	71.50	61.50	57.00	76.00	4.63	NS
Shanks (g/bird)	59.50[d]	100.00[a]	67.00[c]	85.00[b]	60.00[c]	5.75	**
Back (g/bird)	239.50	270.00	233.00	250.00	250.00	14.73	NS
Visceral organs							
Heart (g/bird)	7.00	8.00	7.00	8.00	7.50	0.45	NS
Liver (g/bird)	25.00	26.50	24.50	26.00	14.50	1.78	NS
Small intestine (cm/bird)	169.75	185.00	176.50	202.50	181.50	5.08	NS
Large intestine (cm/bird)	12.00	13.50	13.50	14.50	13.75	0.37	NS
Full gizzard (g/bird)	42.00	95.00	58.00	76.50	80.00	7.20	NS
Kidney (g/bird)	1.25	1.30	1.45	1.55	1.90	0.09	NS

abc= Means on the same row bearing different Superscript are significantly different (P<0.05), ME= Metabolizable energy, SEM= Standard error of mean, LOS= Level of Significance, NS= Not significantly different (P>0.05), *= Significantly different (P<0.05), ECW= Empty carcass weight.

Table 9: Effect of graded levels of TNO on haematological indices of broiler finisher birds

Parameters	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**	**T5 (20%)**	**SEM**	**LOS**
Leukocytes ($x10^3/\mu L$)	89.50	108.50	112.00	126.50	78.50	8.36	NS
Erythrocytes ($x10^6/\mu L$)	2.91	3.25	3.18	3.22	2.87	0.11	NS
Packed cell volume (%)	29.50	30.50	32.00	32.50	29.00	1.17	NS
Haemoglobin (g/dL)	9.80	10.15	10.65	10.80	9.60	0.39	NS
MCV (fl)	101.50	101.75	100.70	101.40	101.00	0.16	NS
MCH (pg)	33.70	33.85	33.50	33.60	33.40	0.08	NS
MCHC (g/dL)	33.20	33.25	33.25	33.20	33.10	0.03	NS

NS= Not significantly different at 5% (P<0.05), LOS= Level of significance, MCV= mean corpuscular volume, MCH= mean corpuscular haemoglobin, MCHC=mean corpuscular haemoglobin concentration.

triglycerides (0.90 vs. 1.15 vs. 1.10 vs. 1.25 and 1.20 mmol/L) increased numerically whereas those of cholesterol, HDLP, LDLP, GOT, GTP and ALP reduced. The values recorded in the present study fell within the normal range for healthy broiler finisher chickens (Jain, 1993). They also agree with the earlier reports of Kwadwo *et al.* (2014), Agbabiaka *et al.* (2012) and Agbabiaka *et al.* (2013). The normal values for serum biochemistry confirm that the birds were not starved, implying that the test ingredient nutritionally adequate for feeding broilers (Alu, 2015a).

Table 10: Effect of graded levels of TNO on serum biochemical variables of broiler finisher birds

Parameters	T1 (0%)	T2 (5%)	T3 (10%)	T4 (15%)	T5 (20%)	SEM	LOS
Total protein (g/dL)	36.00	48.00	39.50	43.50	41.50	1.69	NS
Glucose (mmol/L)	1.25	1.55	1.80	1.55	1.75	0.10	NS
Creatinine (mmol/L)	37.50	37.00	39.50	44.00	42.50	1.21	NS
Cholesterol (mmol/L)	4.80	3.35	3.80	3.20	3.85	0.28	NS
Triglyceride (mmol/L)	0.90	1.15	1.10	1.25	1.20	0.06	NS
HDLP (mmol/L)	0.80	0.65	0.75	0.75	0.70	0.07	NS
LDLP (mmol/L)	0.80	0.75	0.70	0.50	0.70	0.06	NS
GOT (iµ/L)	272.00	207.50	207.50	319.50	282.00	20.74	NS
GPT (iµ/L)	125.00	151.50	69.00	80.50	108.00	11.84	NS
ALP (iµ/L)	446.00	335.00	413.00	453.00	361.00	25.81	NS

NS= Not significantly different at 5% ($P<0.05$), LOS= Level of significance.

Conclusion

The study indicated that poultry farmer can use up to 20% of Tiger nut offal as a replacement for conventional energy source in the diet of broiler chickens without compromising the meat quality and health status of the birds.

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