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Carcass characteristics of finishing broiler chickens fed varying levels of crude fibre and energy in multi-fibre source-based diets

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Abstract

The carcass characteristics of unsexed Obamarshal broiler chickens fed three levels (4, 8 and 12%) of Crude Fibre (CF) and three levels of Metabolisable Energy (ME) at 2600, 2800 and 3000 ME (Kcal/kg) in multi-fibre source-based diets were assessed using a 3x3 factorial design. The nine experimental diets, each for the starter and finisher phases maintained the calorie: protein ratios of 123:1 and 140:1 respectively. Two hundred and sixteen (216) day-old unsexed broiler chicks were allotted at the outset to nine dietary treatments at 24 per diet with 8 birds per replicate. There were 3 replicates per treatment arranged in a completely randomised design. Diets were formulated in accordance with the standard nutritional specifications for the broiler chickens. Feed and water were provided to the birds ad libitum for 8 weeks. Results showed that carcass yield was similar (P>0.05) and maximised (P<0.05) on 8 and 12% CF diets at 2800 and 3000ME (Kcal/kg) with the eviscerated weights of 1.40 and 1.42 kg respectively while carcass fat as per abdominal and gizzard was minimised on 12% CF diet at 2800ME (Kcal/kg) diet. Relative weights of both intestinal organs and length of intestine were increased (P<0.05) in broiler finishers with increasing CF levels while increasing ME levels increased abdominal fat. It can therefore, be concluded that 12% CF diet at 2800 and 3000 ME (Kcal/kg) maximised carcass yield but carcass fat was minimised at 2800 ME (Kcal/kg) diet of broiler chickens in favor of its recommendation for adoption, especially in the tropics.

Keywords: Broiler chicken; crude fibre; metabolisable energy; calorie: protein ratio; carcass

Introduction

Good quality feed is crucial for optimal growth performance in poultry chickens. However, unless precaution is taken, feed quality may be undermined through incorrect amounts and proportions of the essential nutrients to one another in relation to the optimum metabolisable energy (ME) level, thereby resulting in the feeding of substandard feeds to broiler chickens. This will invariably delay attainment of desirable slaughter weightof table birds. The delay has high cost implication for the farmers in terms of increased cost through prolonged feeding to attain slaughter weight due to the use of substandard feeds. With the advancement in poultry nutrition among others, it is now feasible for broiler chickens to attain live and dressed weights of 2 and 1.5kg respectively in 6-8weeks of age (Odunsi *et al.,* 2005) if feeding is adequate as against 10-12 weeks of age in the 1980s and earlier periods.

Until recently, CF is a forgotten essential nutrient in poultry nutrition (Michard, 2011, Esmail, 2012). Hitherto, CF tolerance limit of the broiler chickens was put at 3-5% (Oluyemi and Roberts, 2000; Aduku, 2004; NRC, 2013) without recourse to dietary energy level. Meanwhile, Salami (2016) corroborated the submission of Michard (2011) and Esmail (2012) by reporting that broiler starters and finishers could tolerate 8 and 12% CF levels in their diets at 2800 and 3000 ME (Kcal/kg) respectively without adverse effect on their biologic performance characteristics.

It is not out of place in the nutritional studies to use carcass and organ evaluation alone or in combination with other response criteria to determine the safe inclusion level of a feedstuff as a substitute for another (Adeniji, 2005; Iskwenu *et al.,* 2010; Mathew *et al.,* 2010) or the optimum inclusion level of dietary crude protein (Odunsi *et al.,* 2005), crude fibre (Bamgbose *et al.,* 2004) and calorie: protein ratio (Idowu *et al.,* 2003). CF has been recently exploited to reduce cost of feed per unit weight gain, especially at its optimum inclusion levels in broiler chicken diets (Salami, 2016). Broiler chicken has high propensity to deposit fat in the carcass, which is distasteful to the consumers for health reasons (Shang *et al.,* 2010). Given the cholesterol-lowering effect of fibre (Odunsi *et al.,* 1999 and Shang *et al.,* 2010) and the lower feed cost at the instance of 12% CF tolerance limit for broiler finishers, it is reasonable to expect that this CF tolerance limit would also maximise carcass yield and minimise carcass fat for the health benefit of the consumers. Against this background, this study was, therefore, carried out to assess the effects of varying levels of CF and ME in multi-fibre source-based diets maintained at fixed calorie: protein ratio on the carcass characteristics of broiler chickens.

Materials and Methods

Experimental site

The study was conducted at the Poultry unit of the Teaching and Research farm, Emmanuel Alayande College of Education, Oyo, Nigeria. Oyo is located approximately along latitude 7^0 51^1 North of the equator and longitude 3^0 57^1 East of the Greenwich meridian and 850m above sea level. The annual average rainfall is 1163mm while annual mean temperature is 27^0C and annual mean relative humidity is 82% (Iwena, 2012).

Experimental diets, birds and management

Nine treatment diets were formulated containing three metabolisable energy (ME) levels (2600, 2800 and 3000 ME Kcal/Kg) and three dietary crude fibre (CF) levels (4, 8 and 12%) per energy level to give a 3 X 3 factorial design at both starter and finisher phases. The calculated crude protein content of the starter phase varied from 21-24% with average calorie: protein ratio of 123:1 while the values for the finisher phase varied from 18-21% and calorie: protein ratio of 140:1 in accordance with Aduku (2004). The calorie: protein ratio was kept constant despite the variations in the inclusion levels of maize, rice offal, wheat offal, palm kernel meal, blood meal and palm oil in order to eliminate the effect of varying calorie: protein ratio on voluntary feed intake of the birds (Tion *et al.,* 2005).The compositions of the finisher diets are shown in Table 1. Essentially, dietary inclusion levels of wheat offal and palm kernel cake did not exceed their respective recommended safe levels (10 – 30% and 40%) in broiler diets (Babatunde and Oluyemi, 2000; Sundu *et al.,* 2006), while rice offal was used to vary dietary fibre level at the expense of maize. Inclusion of blood meal did not exceed the tolerance level of 9% (Donkoh *et al.,* 2001). Palm oil was added to unify the calorie content of the diets at each energy level and did not exceed the level (16% of diet), which animals can tolerate (Atteh, 2002). Sterilized sand was used at maximum of 5%

in diet A (Adeniji, 2010) to fix dietary crude fibre at 4%. Sand was sterilized in a 'gari' frying pan at 250°C for 10 minutes to eliminate the presence of microorganisms in the sand and allowed to cool at room temperature before use.

Table1: Percentage Composition of Experimental diets for Broiler Finishers

	2,600 ME (Kcal/Kg)			**2,800** ME (Kcal/Kg)			**3,000** ME (Kcal/Kg)		
Feed ingredients	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Maize(2%CF)	46	39	20	48	38	26	43	30	21
Wheat Offal(8.5CF)	18	19	18	12	12	5	12	12	3
Rice Offal(38%CF)	2	12	23	2	10	24	2	10	25
Palm Kernel Cake(17.5%CF)	3	2	3	5	10	5	5	10	4
Groundnut Cake(5%CF)	14	15	18	13	12	18	12	12	18
Blood meal(1%CF)	4	4	4	6	6	6	8	8	8
Danish Fish Meal (1%CF)	2	2	2	4	3	3	4	4	4
Palm Oil	1	2	7	2	4	8	6	9	12
Sterilised sand	5	-	-	3	-	-	3	-	-
[a]Fixed Ingredients	5	5	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100	100	100
Calculated ME (kcal/kg):	2612	2622	2605	2808	2807	2813	2985	3015	2997
[b]Determined Fractions (%):									
Dry matter	90.3	90.1	90.1	90.2	90.4	89.0	90.1	88.2	88.4
Crude protein	17.7	17.8	17.7	19.5	19.4	19.3	20.1	20.1	20.2
Crude fat	4.44	6.45	11.4	5.41	7.52	12.6	8.45	11.7	15.4
Nitrogen – free extract	52.1	49.1	42.8	49.9	45.7	37.4	48.3	39.5	32.8
Crude fibre	3.95	7.68	11.80	4.05	7.88	11.85	4.00	7.75	11.9
Ash	12.4	12.5	12.6	12.4	12.7	12.5	13.2	13.1	13.1

[a]Made up of 2.5% bone meal,2% oyster shell, 0.25% salt and 0.25% broiler premix.
[b]Means of triplicate determinations.

A total of 216 day-old unsexed Obamarshal strain of broiler chicks were allotted to the nine treatment diets at 24 birds per diet and replicated thrice at 8 birds per replicate arranged in acompletely randomized design.Fine water erosion sand was used as the litter material and at a depth of 4 to 5cm. so as to prevent the birds from picking fibre from litter (Hetland *et al.,* 2004; Esmail, 2012). Routine medications and vaccinations were also followed as and when due (Salami, 2009).

Data Collection

At day 56 of the feeding trial, four (4) birds made up of 2males and 2females per treatment with body weight closest to the average of the treatment group were sampled, each of them serving as a replicate to make 4replicates per treatment. The sampled birds were denied feed but not water for 14 hours, weighed, slaughtered and allowed to bleed thoroughly to obtain pre- and post- slaughter weights respectively. The carcass was de-feathered, cleaned to obtain plucked weight andalso eviscerated to obtain eviscerated or dressed weight andexpressed as percentage of pre-slaughter weight as described by Oluyemi and Roberts (2000). The visceral organs and intestinal organs were carefully excised and weighed usinga sensitive scale and the weight was also expressed as percentage of pre-slaughter weight. The length of some parts of the gut was also measured using a meter rule and expressed in relation to the pre-slaughter weight of the sacrificed birds (cm/kg).

Data collected were subjected to *analysis of* variance in accordance with 3X3 factorial design made up of 3 levels of metabolisable energy (2600, 2800 and 3000ME (Kcal/kg) and 3 levels of crude fibre (4, 8 and 12%) per energy level using SAS (2000) statistical package. Means were also separated using Duncan's Multiple Range Test of the same package at 5% probability level.

Results

The pre-slaughter, post-slaughter, plucked and eviscerated or dressed weights of sampled male and female broiler chickens at 56 days of age indicated that these carcass parameters were optimized (P<0.05) at 8 and 12% crude fibre levels (Table 2) and at 2800 and 3000ME (Kcal/kg)(Table 3), thereby indicating that 4% CF at the three energy levels and 2600Kcal ME/Kg were not adequate for the broilers as confirmed by the interaction effect (Table 4). The lengths of the small intestine, large intestine, paired caeca and colo-rectum (Table 2) increased significantly (P<0.05) as dietary crude fibre level increased. There was no significant effect of dietary ME level on gut length except the paired caeca which was inconsistent (Table 3). With the exception of the large intestine and colo-rectum of the birds on the 4% CF diets across energy levels, which were significantly (P<0.05) shorter because of lower crude fibre content, interaction effect indicated that the length of the organs increased (P<0.05) as dietary crude fibre level increased across the dietary energy levels (Table 4). Within the range of crude

Table 2: Effect of varying levels of dietary crude fibre on carcass characteristics of broiler finishers (percent pre-slaughter weight)

Carcass parameters	Dietary crude fibre level (%)			± SEM
	4	8	12	
Pre-slaughter weight at 56 days(Kg)	2.01[b]	2.07[a]	2.06[a]	0.01
Post-slaughter weight (%)	94.31	93.55	93.19	0.36
Plucked weight (%)	90.7	90.8	89.9	0.22
Eviscerated weight (%)	68.1	68.5	68.1	0.31
Gut length (cm/kg):				
Small intestine	86.69[c]	90.45[b]	96.92[a]	2.33
Large intestine	21.7[c]	23.7[b]	27.1[a]	0.64
Combined caeca	17.6[b]	18.9[b]	21.9[a]	0.46
Colo-rectum	3.49[c]	4.79[b]	6.10[a]	0.17

[a,b,c]Means within the same row bearing different superscripts are significantly different(P<0.05).

Table 3: Effect of varying levels of dietary energy on carcass characteristics of broiler finishers

Carcass parameters	Dietary ME level (Kcal./Kg)			± SEM
	2600	2800	3000	
Pre-slaughter weight at 56 days (Kg)	2.01[b]	2.01[b]	2.11[a]	0.01
Post-slaughter weight (%)	93.69	94.32	93.04	0.36
Plucked weight (%)	89.93	91.70	89.76	0.22
Eviscerated weight (%)	68.29	68.63	67.68	0.31
Gut length (cm/kg):				
Small intestine	91.04	93.27	91.75	2.33
Large intestine	23.65	24.53	24.33	0.64
Combined caeca	18.75[b]	21.02[a]	18.78[b]	0.46
Colo-rectum	4.60	5.02	4.77	0.17

[a,bc]Means within the same row bearing different superscripts are significantly different(P<0.05).

Table 4: Interaction effects of varying dietary crude fibre and energy levels on carcass characteristics of broiler finishers

	2600			2800			3000ME (Kcal/kg)			
	A	B	C	D	E	F	G	H	I	
Carcass parameters	**4**	**8**	**12%CF**	**4**	**8**	**12%CF**	**4**	**8**	**12%CF**	**± SEM**
Pre-slaughter weight at 56 days(Kg)	1.97^{c}	2.03^{bc}	2.04^{bc}	1.98^{bc}	2.00^{bc}	2.06^{b}	2.07^{b}	2.19^{a}	2.08^{b}	0.03
Post-slaughter weight (%)	93.00^{ab}	93.86^{ab}	94.21^{ab}	96.27^{a}	93.53^{ab}	93.17^{ab}	93.68^{ab}	93.27^{ab}	92.18^{b}	1.01
Plucked weight (%)	89.22^{cd}	90.86^{abc}	89.71^{bcd}	92.43^{a}	91.59^{ab}	91.09^{abc}	90.56^{abcd}	89.83^{bcd}	88.89^{d}	0.62
Eviscerated weight (%)	67.3^{ab}	67.8^{ab}	69.8^{a}	68.1^{ab}	69.7^{a}	68.1^{ab}	68.8^{ab}	68.0^{ab}	66.23^{b}	0.87
Gut length (cm/kg):										
Small intestine	89.6^{b}	90.1^{ab}	93.5^{ab}	89.9^{b}	93.5^{ab}	96.4^{ab}	86.7^{b}	87.7^{b}	100.8^{a}	3.11
Large intestine	20.74^{c}	23.58^{bc}	26.64^{a}	21.97^{bc}	24.40^{ab}	27.24^{a}	22.44^{bc}	23.01^{bc}	27.54^{a}	1.10
Combined caeca	17.07^{b}	18.66^{ab}	20.51^{a}	18.09^{ab}	19.44^{a}	20.41^{a}	17.74^{b}	18.75^{ab}	19.86^{a}	0.65
Colo-rectum	3.70^{c}	4.48^{b}	5.62^{ab}	3.52^{c}	4.14^{b}	6.39^{a}	3.25^{c}	4.76^{b}	6.30^{a}	0.24

^{a,b,c,dc}Means within the same row bearing different superscripts are significantly different($P<0.05$).

fibre and dietary energy levels, length of intestines and combined caeca increased as dietary fibre increased as a modification of the gut to accommodate more feed due to the challenge of lower bulk density of the feed as CF level increased.

The weights of crop, heart, lung, kidney, giblet and trachea were not affected (P>0.05) by dietary fibre, energy levels or their interactions (Tables 5, 6 and 7). While proventriculus and gizzard weights were not affected significantly (P>0.05) by dietary

Table 5: Effect of varying levels of dietary crude fibre on organ weight of broiler finishers

	Dietary crude fibre level (%)			
Organ (as % of pre-slaughter weight)	**4**	**8**	**12**	**± SEM**
Trachea	0.13	0.12	0.13	0.01
Heart	0.44	0.45	0.44	0.03
Lung	0.47	0.46	0.52	0.03
Kidney	0.68^{b}	0.73^{a}	0.70^{ab}	0.03
Spleen	0.17^{a}	0.11^{b}	0.12^{b}	0.01
Giblet (liver and bile)	1.76^{b}	1.86^{ab}	1.90^{a}	0.07
Crop	0.63	0.60	0.67	0.03
Proventriculus	0.51^{c}	0.66^{b}	0.72^{a}	0.03
Intact gizzard	2.39^{b}	2.94^{ab}	3.11^{a}	0.06
Cleaned gizzard	1.99	2.30	2.42	0.06
Gizzard fat	0.65^{a}	0.36^{b}	0.22^{c}	0.04
Abdominal fat	2.06^{a}	1.39^{b}	1.16^{c}	0.10
Colo-rectum	0.37^{a}	0.21^{b}	0.24^{b}	0.01
Combined caeca	0.46^{c}	0.65^{b}	0.80^{a}	0.03
Small intestine	2.83^{b}	3.41^{a}	3.77^{a}	0.09
Large intestine	0.87^{b}	0.85^{b}	0.96^{a}	0.04

[a,bc]Means within the same row bearing different superscripts are significantly different(P<0.05).

Table 6: Effect of varying levels of dietary energy on organ weight of broiler finishers

	Dietary ME level (Kcal./Kg)			
Organ (as % of pre-slaughter weight)	**2600**	**2800**	**3000**	**± SEM**
Trachea	0.13	0.13	0.12	0.01
Heart	0.41	0.47	0.46	0.03
Lung	0.48	0.54	0.43	0.03
Kidney	0.68^{b}	0.69^{b}	0.74^{a}	0.03
Spleen	0.19^{a}	0.11^{b}	0.11^{b}	0.01
Giblet (liver and bile)	1.78	1.94	1.80	0.07
Crop	0.67	0.60	0.62	0.03
Proventriculus	0.60	0.64	0.64	0.03
Intact gizzard	2.82	2.97	2.65	0.06
Cleaned gizzard	2.33	2.26	2.12	0.06
Gizzard fat	0.50^{a}	0.35^{b}	0.38^{b}	0.04
Abdominal fat	1.42^{b}	1.47^{b}	1.71^{a}	0.10
Colo-rectum	0.40^{a}	0.20^{b}	0.21^{b}	0.01
Combined caeca	0.65	0.60	0.66	0.03
Small intestine	3.20	3.55	3.25	0.09
Large intestine	1.01^{a}	0.80^{b}	0.88^{ab}	0.04

[a,bc]Means within the same row bearing different superscripts are significantly different(P<0.05).

Table 7: Interaction effects of varying dietary crude fibre and energy levels on organ weights of broiler finishers

	2600			2800			3000 ME (Kcal/kg)			
	A	B	C	D	E	F	G	H	I	
Organ (as % of pre-slaughter weight)	**4**	**8**	**12%CF**	**4**	**8**	**12CF**	**4**	**8**	**12%CF**	**± SEM**
Trachea	0.13	0.13	0.14	0.14	0.13	0.12	0.12	0.12	0.13	0.02
Heart	0.34	0.44	0.45	0.51	0.53	0.37	0.48	0.39	0.50	0.10
Lung	0.52^{ab}	0.44^{b}	0.51^{ab}	0.51^{ab}	0.51^{ab}	0.61^{a}	0.39^{b}	0.44^{b}	0.45^{b}	0.11
Kidney	0.67	0.68	0.70	0.66	0.78	0.65	0.72	0.75	0.75	0.07
Spleen	0.29	0.14	0.13	0.12	0.10	0.12	0.11	0.10	0.12	0.14
Giblet (liver and bile)	1.32	2.03	2.00	2.17	1.82	1.84	1.79	1.74	1.87	0.35
Crop	0.88	0.50	0.65	0.51	0.64	0.66	0.51	0.65	0.70	0.30
Proventriculus	0.49^{d}	0.58^{bc}	0.72^{ab}	0.53^{cd}	0.72^{ab}	0.68^{abc}	0.50^{d}	0.67^{abc}	0.76^{a}	0.05
Intact gizzard	2.13	3.23	3.11	2.76	3.16	2.98	2.28	2.43	3.23	0.46
Cleaned gizzard	2.05	2.49	2.46	2.09	2.45	2.25	1.84	1.96	2.56	0.87
Gizzard fat	0.94^{a}	0.36^{bc}	0.22^{c}	0.47^{b}	0.35^{bc}	0.23^{c}	0.55^{b}	0.37^{bc}	0.23^{c}	0.26
Abdominal fat	2.00^{ab}	1.32^{ab}	0.96^{b}	1.76^{ab}	1.48^{ab}	1.17^{ab}	2.42^{a}	1.37^{ab}	1.36^{ab}	0.39
Colo-rectum	0.76^{a}	0.22^{b}	0.22^{b}	0.17^{b}	0.21^{b}	0.23^{b}	0.19^{b}	1.19^{b}	0.27^{b}	0.13
Combined caeca	0.44^{c}	0.68^{abc}	0.84^{a}	0.50^{bc}	0.62^{abc}	0.70^{abc}	0.46^{c}	0.65^{abc}	0.88^{a}	0.11
Small intestine	2.56^{b}	3.48^{ab}	3.56^{ab}	3.32^{ab}	3.40^{ab}	3.94^{a}	2.60^{ab}	3.34^{ab}	3.81^{ab}	0.43
Large intestine	1.31^{a}	0.90^{c}	0.82^{cd}	0.66^{d}	0.83^{cd}	0.92^{bc}	0.64^{d}	0.84^{cd}	1.15^{ab}	0.07

[a,b,c,d]Means within the same rows bearing unidentical superscripts differ ($P<0.05$) significantly while those without superscript are similar ($P>0.05$)

energy level, dietary fibre level increased (P<0.05) the weight of these two organs. Within the dietary energy levels, proventriculus and gizzard weights increased (P<0.05) as crude fibre levels increased (Table 7). Abdominal fat and gizzard fat decreased in weight as dietary crude fibre increased, while both of them increased in weight as dietary energy level increased (Table 6). The least weight of abdominal fat and gizzard fat was recorded for birds on 12% crude fibre diet across the three energy levels (Table 7). The weight of the combined caeca and the intestines of the birds increased (P<0.05) as dietary crude fibre increased. However, there was no significant effect of dietary energy on the caeca and the intestines.

Discussion

The pre-slaughter weights showed that broiler finishers fed 8 and12% crude fibre diets at 2800 and 3000ME (Kcal/kg) were better than those placed on 2600 at all CF levels. However, eviscerated percentage revealed comparable values for all energy and crude fibre levels, which are similar to the values earlier reported (Odunsi *et al.* 2005 and Isikwenu *et al.,* 2010). Meanwhile, Bamgbose *et al.* (2004) observed depressed carcass yield in 8-week old cockerels fed 13 to 19% crude fibre diets. At 8 weeks of age, the cockerels used by Bamgbose *et al.,* (2004) were younger physiologically to cope with the challenge of high crude fibre levels fed before slaughter and this might have accounted for the depressed carcass yield since cockerels are expected to tolerate more fibre at older age than the broilers (Oyawoye and Nelson, 1999; Salami *et al*., 2003). The observed values of dressed carcass weight showed that 12% CF at 2800 and 3000ME (Kcal/kg) are adequate as previously reported for growth performance indices and blood profile of finishing broiler chickens (Salami, 2016).

The non-significant main effects of dietary crude fibre and energy levels and also their interaction on the visceral organs are in accordance with the report of Bamgbose *et al.* (2004). However, the various parts of the gut notably proventriculus, gizzard and the paired caeca responded significantly to the dietary fibre level in this study. This is also concordant with the previous findings (Ibiyo and Atteh, 2005; Adeniji, 2005; and Isikwenu *et al.,* 2010).The weights of abdominal fat and gizzard fat were also reduced significantly by dietary fibre and increased by energy levels as reported previously (Odunsi *et al.,* 1999 and Adeniji, 2005).This would have implication for carcass fat reduction in view of the health risk of animal fat to the consumers of animal products. The non-significant effect of fibre and energy levels on the crop weight (as a temporary storage organ of feed) was uncommon since other parts of the gut such as gizzard, intestines and paired caeca were increased in weight.The gizzard, intestines and combined caeca increased significantly in weight and in length in response to the increasing crude fibre levels in the diets. The interaction of both variable factors showed an increment in the weight of the paired caeca and the intestines as dietary crude fibre increased across the energy levels due to hypertrophy of these organs (Adeniji, 2005) to increase their capacity to accommodate more feed for fermentation and digestion processes respectively.

Conclusion and Recommendation

It is evident from the results of this study that adequate CF (12%) and ME (2800) levels are essential for maximum carcass yield in broiler finishers. Increasing CF level reduced abdominal fat and gizzard fat, while increasing ME level increased the weight of the adipose tissues, thereby revalidating that CF can be exploited to reduce carcass fat to produce lean meat.

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