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Diet Selection Preference, Growth Performance and Meat Quality of Broiler Chickens raised on varying Dietary Energy and Protein Levels

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ABSTRACT: The growth performance and meat quality of three hundred and thirty broiler chickens provided diets containing varying energy and protein contents were examined in this study. Five experimental diets – Control A (12.14 MJ ME/kg; 194g/kg CP); B (10.67 MJ ME/kg; 166g/kg CP); C (10.79 MJ ME/kg; 237g/kg CP); D (14.12 MJ ME/kg; 166g/kg CP) and E (13.72 MJ ME/kg; 239g/kg CP) were arranged into 11 experimental treatments which comprised feeding single and choice diets. So, treatments were T1 (diet A), T2 (diet B), T3 (diet C), T4 (diet D), T5 (diet E), T6 (diets B and C), T7 (diets B and D), T8 (diets B and E), T9 (diets C and D), T10 (diets C and E) and T11 (diets D and E). Feed intake and weight gain of chickens fed the dietary treatments and moisture content, lipid content and oxidative stability of meat samples from them were assessed. Final live weight and total weight gain were not significantly (P>0.05) influenced by dietary treatments. Total feed intake and feed conversion ratio were significantly (P<0.001) highest for birds on treatments based on low energy diets. Moisture and lipid contents of thigh muscle were significantly (P<0.05) higher than those of drumstick and breast muscles. Oxidative deterioration of meat was significant (P<0.001) among treatments, values for day 6 were generally higher than those of day 1. In conclusion, broiler chickens can select balanced diet from an option of feeds differing in energy and protein levels. The protein content of broiler chicken diets should be given adequate attention when formulating feed for optimal productivity.

Keywords: Broiler meat, Choice feeding, Finisher diet, Oxidative stability

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INTRODUCTION

The cost of feeding accounts for between 60 and 80% of the total production costs of broiler chickens depending on the raw materials used (Oluyemi and Roberts, 2000). The phrase "free choice feeding" is a method which allows diet selection from different feeds (Pousga *et al.*, 2005). Choice feeding in poultry production is based on the fact that birds can choose between feed ingredients served to them to meet their performance and maintenance needs. This choice is not possible when a single conventional feed is given to them (Olver and Malan, 2000).

Dietary energy and protein are probably the major factors determining feed intake, although the importance of some specific compounds, such as lysine, methionine and minerals cannot be under-estimated. Factors such as high cost of feeds arising largely from fluctuations in feed supplies, rising prices of ingredients and poor quality feeds (Ogunwolere and Onwuka, 1997), the need to re-evaluate the optimum protein content of broiler diets especially in the tropics (Onibi *et al.,* 1999) and differences in broiler genotypes (Sterling *et al.*, 2006; Hristakieva *et al.*, 2014) are justifications for diet selection experiments. Therefore, this study was designed

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to investigate the growth performance and meat quality of broilers fed diets of different energy and protein levels either singly or in combination (choice).

MATERIALS AND METHODS

A total of 330 chicks were selected at the end of a 3-week pre-experimental brooding period during which chicks were fed commercial broiler starter diets (232 g/kg CP and 12.22 MJ ME/kg) *ad libitum*. The study involved the use of five finisher experimental diets (A, B, C, D and E) fed

Table 1: Experimental treatments

Treatment (T)	Diet/dietary choice combination
1	A (Control)
2	B (Low energy-low protein)
3	C (Low energy-high protein)
4	D (High energy-low protein)
5	E (High energy-high protein)
6	B and C
7	B and D
8	B and E
9	C and D
10	C and E
11	D and E

Table 2: Gross and calculated compositions of experimental diets (g/kg)

Ingredients	Diet A	Diet B	Diet C	Diet D	Diet E
Maize	450.00	300.00	200.00	680.00	500.00
Maize offal	100.00	200.00	200.00	-	-
Wheat offal	-	140.00	69.00	-	-
Soyabean meal (42%)	250.00	150.00	360.00	200.00	360.00
Fishmeal (65%)	15.00	-	15.00	20.00	58.00
Palm kernel cake	50.00	40.00	-	-	-
Brewers dried grain	80.00	100.00	100.00	-	-
Rice bran	-	24.00	20.00	-	-
Palm oil	15.00	-	-	52.00	52.00
Bone meal	27.00	30.00	25.00	27.00	20.00
Salt	5.00	5.00	5.00	5.00	5.00
Lysine	2.00	4.00	-	4.00	-
Methionine	3.00	4.00	3.00	4.00	2.50
Premix	2.50	2.50	2.50	2.50	2.50
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated chemical composition					
Crude protein g/kg	194.20	166.00	237.00	165.50	238.90
Metabolizable energy MJ/kg	12.14	10.67	10.79	14.12	13.72
Ether extract g/kg	50.50	39.30	42.00	83.00	74.60
Crude fibre g/kg	59.40	79.60	59.80	26.90	10.60
Calcium g/kg	11.90	11.90	11.20	11.90	11.70
Phosphorus g/kg	6.80	6.60	7.20	6.54	8.80
Lysine g/kg	12.10	12.00	13.80	12.20	13.90
Methionine g/kg	6.90	6.80	6.80	6.80	6.60
Energy: Protein	14.98	15.35	10.88	20.38	13.73

to the chickens as single and choice diets to make eleven (11) experimental treatments as shown in Table 1. These diets were formulated at the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria. Diet A served as the control containing optimum energy-optimum protein (12.14 MJ ME/kg; 194 g/kg CP). Diets B, C, D and E contained low energy-low protein (10.67 MJ ME/kg; 166 g/kg CP), low energy-high protein (10.79 MJ ME/kg; 237 g/kg CP), high energy-low protein (14.12 MJ ME/kg; 166 g/kg CP) and high energy-high protein (13.72 MJ ME/kg; 239 g/kg CP) respectively. Gross and calculated compositions and proximate composition of the diets are shown in Tables 2 and 3 respectively. The chicks were carefully weighed and assigned to the 11 experimental treatments. Each treatment was replicated thrice with 10 chicks per replicate. Feed and water were provided *ad libitum*.

During the 5-week experimental period, feed consumption and weight of birds per replicate were measured weekly. At the end of the experiment, 3 birds/replicate, with closest live weights to the average group weight were slaughtered for measurements of moisture and lipid contents, and oxidative stability of meat from the broiler chickens. Oxidative stability of meat samples from the chest, drumstick and thigh muscles was determined on days 1 and 6 of refrigerated storage at 4ºC. Moisture and lipid contents of the meat samples were determined by the AOAC (1995) method.

All data were subjected to one-way analysis of variance and factorial analysis as appropriate. The Minitab Statistical Package (ver. 10.2, Minitab Inc., USA) was used for the analysis.

Table 3: Proximate composition (%) of experimental diets

Diet	Dry Matter	Crude Protein	Crude Fibre	Ether Extract	Ash	Nitrogen Free Extract
A	92.26	20.06	4.99	5.74	7.32	54.15
B	89.26	16.64	8.68	3.33	8.07	52.54
C	89.74	23.94	4.82	5.52	8.06	47.40
D	92.74	16.45	2.25	8.76	6.04	59.24
E	92.08	23.57	1.84	7.75	6.33	52.59

RESULTS AND DISCUSSION

Diet A which had 194.20 g/kg CP and 12.14 MJ ME/kg diet was chosen as the control diet for the broiler chicken finishers. These levels would adequately meet the protein and energy requirements of broiler chickens at the finishing phase according to NRC (1994) and Oluyemi and Roberts (2000). Energy to protein ratios of the diets ranged between 10.88 in diet C (low energy-high protein diet) to 20.38 in diet D (high energy-low protein diet).

The performance of the broiler chickens fed diets with varying energy and protein contents is shown in Table 4. The final live weight and total weight gain were not significantly ($p>0.05$) influenced by the dietary treatments. However, weight gain was numerically highest for birds on T5 (2011.30±77.40 g/bird) and lowest for birds on T4 (1669.70±32.70 g/bird) among birds fed single diets. And birds on T10 (1930.00±231.00 g/bird) had the highest weight gain among birds given choice diets.

The total feed intake and feed conversion ratio (FCR) were significantly ($p<0.05$) influenced by dietary treatments. The total feed intake was significantly lowest for birds on T4 (3217.00±366.00 g/bird) and highest for birds on T2 (4772.00±322.00 g/bird). When birds were given choices, those on T11 (3908.40±50.00 g/bird) had lowest total feed intake while birds on T6 (5203.30±323.30 g/bird) had the highest value. Generally, birds on T4 and T5 (1.90±0.30 and 1.90±0.10 respectively) had the lowest value for

Table 4: Performance of broiler chickens on experimental diets

Parameters /Treatment (T)	Initial live weight (g/bird)	Final live weight (g/bird)	Total feed intake (g/bird)	Total weight gain (g/bird)	Feed conversion ratio
1	366.70±20.80	2184.20±92.10	4036.60±206.20[bc]	1817.50±71.30	2.20±0.10[bc]
2	346.70±45.10	2021.70±84.10	4772.00±322.00[e]	1675.00±39.00	2.90±0.30[e]
3	323.30±15.30	2033.30±118.70	4747.00±302.00[de]	1710.00±103.40	2.80±0.10[e]
4	335.30±15.00	2005.00±47.70	3217.00±366.00[a]	1669.70±32.70	1.90±0.20[a]
5	322.00±17.10	2333.30±94.50	3736.70±50.30[b]	2011.30±77.40	1.90±0.10[a]
6	334.70±31.40	2116.70±66.60	5203.30±323.30[e]	1782.00±84.90	2.90±0.30[e]
7	351.30±12.10	2008.30±63.30	4244.10±320.40[bcd]	1657.00±75.40	2.60±0.10[e]
8	366.70±30.60	2210.00±275.00	4203.70±350.80[bc]	1843.00±245.00	2.30±0.20[cd]
9	335.30±22.50	2140.00±105.80	4113.30±382.10[bc]	1804.70±83.60	2.30±0.20[cd]
10	336.70±15.30	2267.00±225.00	4335.80±339.00[ce]	1930.00±231.00	2.30±0.30[cd]
11	333.30±41.60	2212.50±161.60	3908.40±50.00[bc]	1879.00±179.00	2.10±0.20[ab]

Mean ± Standard deviation
Means with different superscripts along the same column are significantly different (p<0.05)

FCR while those on T2 and T6 had the highest value (2.90±0.30). The numerically highest weight gain (P>0.05) recorded for birds on T5 among birds fed the single diets can be attributed to the synergistic effects of both high energy and high protein as energy is needed for proper body functioning and protein for tissue accretion (Jafarnejad and Sadegh, 2011). This implies a better feed utilization of feed with higher concentrations of nutrients (Perween *et al*., 2016). These birds performed better than birds on the control diet. Birds on T4 were fed a diet that contained higher energy than the optimum but low protein. As the birds ate to meet their energy requirement, they could only consume less of the diet which means that the birds had access to less than required quantity of protein needed for their growth. Birds on T2 had lowest feed intake because their feed contained high energy and low protein. Due to high energy, they consumed less feed and as such consumed less of the low protein diet. The performance records of birds fed the single diets in this study showed that although energy and protein are major factors to be considered in optimizing broiler chicken's growth (Ojewola and Longe, 1999), protein is more important. Among the choice-fed birds, T10 had the highest weight gain as the two choices given to them had high protein content. Birds on T6 were given choices between two low energy diets. This might be the reason for the highest FCR value recorded since weight gain in relation to feed intake determines the FCR. The low energy diets would have prompted them to eat more. Rosa *et al.* (2007) reported that high energy diets promotes weight gain and fat deposition, so on the contrary, low energy diets will not promote weight gain.

Moisture and lipid contents of muscles of the chickens are shown in Table 5. The moisture content was not significantly (p>0.05) affected by the experimental treatments. Although, there was a significant effect (p<0.05) of muscle type, with thigh having higher moisture (73.18±1.93%) than drumstick (72.06±2.05%) and breast (71.94±2.19%). This is in line with Yu *et al.* (2011) which reported that red muscles like thigh contain more water and fat than white muscles like chest. The lipid content was significantly influenced (p<0.001) by experimental treatments and muscle type. The lipid content was highest in the thigh muscle (9.83±1.18%). The lipid content of drumstick was 7.37±0.74% and breast muscle had 5.62±0.96%. The moisture contents obtained in this study are about the 74%

Table 5: Moisture and lipid contents (%) of muscle and oxidative stability (mgMDA/kg muscle) of refrigerated meat from broiler chickens on single or choice diets with varying energy and protein levels

Treatments (T)	Muscle Type	Moisture	Lipid	Oxidative stability	
Mean effect of treatment				Day 1	Day 6
1		71.44±1.88	7.65±1.82^{abc}	0.60±0.14^{a}	1.24±0.35^{abc}
2		73.33±1.58	7.31±1.60^{ab}	0.57±0.14^{a}	1.25±0.31^{abc}
3		71.56±2.60	7.02±2.09^{a}	0.64±0.15^{a}	1.32±0.34^{abc}
4		72.56±1.88	9.08±1.97^{bc}	0.77±0.11^{b}	1.50±0.27^{bc}
5		71.22±1.72	7.20±1.88^{a}	0.61±0.14^{a}	1.14±0.42^{a}
6		72.22±2.68	7.18±1.94^{a}	0.63±0.17^{a}	1.32±0.29^{abc}
7		73.22±1.92	7.20±1.89^{a}	0.59±0.12^{a}	1.15±0.46^{a}
8		72.67±2.35	7.53±1.89^{bc}	0.60±0.13^{a}	1.27±0.30^{abc}
9		72.11±2.03	7.24±1.96^{a}	0.61±0.13^{a}	1.20±0.48^{ab}
10		72.78±2.11	6.99±1.92^{a}	0.62±0.15^{a}	1.13±0.36^{a}
11		73.22±2.05	9.26±2.27^{c}	0.79±0.14^{b}	1.54±0.18^{c}
Mean effect of muscle type					
Breast		71.94±2.19^{d}	5.62±0.96^{d}	0.53±0.10^{d}	1.01±0.23^{d}
Drumstick		72.06±2.05^{d}	7.37±0.74^{e}	0.61±0.10^{e}	1.22±0.22^{e}
Thigh		73.18±1.93^{e}	9.83±1.18^{f}	0.78±0.12^{f}	1.60±0.32^{f}
Interactive effect of treatment and muscle type					
1	Breast	71.67±2.52	5.85±0.89	0.50±0.10	0.95±0.06
	Drumstick	71.67±2.08	7.30±0.56	0.51±0.89	1.08±0.03
	Thigh	71.00±1.73	9.80±0.46	0.74±0.11	1.68±0.14
2	Breast	72.33±2.52	5.58±0.70	0.74±0.07	0.94±0.17
	Drumstick	74.00±1.00	7.30±0.62	0.53±0.07	1.19±0.02
	Thigh	73.67±0.58	9.07±0.47	0.72±0.14	1.62±0.08
3	Breast	70.00±1.73	4.97±0.99	0.51±0.12	0.98±0.19
	Drumstick	70.33±1.53	6.67±0.71	0.62±0.08	1.25±0.08
	Thigh	74.33±2.08	9.43±0.91	0.78±0.09	1.72±0.09
4	Breast	71.00±2.00	7.23±0.45	0.67±0.03	1.25±0.24
	Drumstick	72.67±1.53	8.47±0.55	0.76±0.07	1.55±0.05
	Thigh	74.00±1.00	7.23±0.45	0.86±0.12	1.69±0.28
5	Breast	71.00±2.00	5.07±0.32	0.50±0.07	0.95±0.06
	Drumstick	70.67±1.53	7.20±0.27	0.58±0.08	1.13±0.06
	Thigh	72.00±2.00	9.33±0.59	0.75±0.12	1.33±0.76
6	Breast	71.00±2.65	5.07±0.15	0.51±0.06	1.04±0.07
	Drumstick	73.00±2.00	5.07±0.15	0.56±0.10	1.27±0.06
	Thigh	72.67±3.79	7.10±0.82	0.81±0.15	1.67±0.14
7	Breast	73.67±2.52	5.27±0.35	0.51±0.04	0.67±0.48
	Drumstick	72.33±1.53	6.90±0.44	0.56±0.10	1.22±0.07
	Thigh	73.67±2.08	9.43±0.85	0.73±0.06	1.58±0.05
8	Breast	73.00±1.00	5.53±0.73	0.51±0.12	0.99±0.11
	Drumstick	71.67±3.79	7.53±0.50	0.57±0.05	1.18±0.08
	Thigh	73.33±2.08	7.00±0.53	0.73±0.13	1.63±0.10
9	Breast	71.67±3.06	5.17±0.32	0.51±0.07	0.96±0.03
	Drumstick	71.67±1.53	7.00±0.53	0.58±0.09	1.18±0.08
	Thigh	73.00±1.73	9.57±0.58	0.73±0.12	1.74±0.09
10	Breast	73.67±2.08	4.80±0.53	0.45±0.07	0.99±0.10
	Drumstick	71.33±2.52	7.17±0.32	0.67±0.04	1.18±0.02
	Thigh	73.33±1.53	9.00±1.00	0.75±0.12	1.22±0.67
11	Breast	72.33±2.08	7.23±0.51	0.67±0.04	1.38±0.10
	Drumstick	73.33±2.52	8.47±0.65	0.74±0.07	1.49±0.09
	Thigh	74.00±2.00	12.07±1.01	0.95±2.00	1.74±0.09
Statistical significance					
Treatment		NS	***	***	**
Muscle type		*	***	***	***
Treatment × Muscle type		NS	NS	NS	NS

*Mean±SD NS = Not Significant (p>0.05) *= p<0.05 ***= p<0.001*

Mean with different superscripts within the same column and for the same parameter effect are significant (p<0.05) recorded in Aduku and Olukosi (2012) for poultry. The lipid content for breast (5.62±0.96%), drumstick (7.37±0.74%) and thigh (9.83±1.18%) were also within the range of 4 and 12% reported by Aduku and Olukosi (2012) for poultry. In line with this, the treatment effect revealed that the high energy content of diets fed to birds on T4 and T11 produced broiler chickens with higher lipid contents in the muscle. However, birds on low energy diets (T2, T3, T6 and T10) had lower lipid contents in the muscles. Significant differences were obtained due to muscle types. From the reports of Aduku and Olukosi (2012) and Onibi (2006), lipid content is most variable components of meat and variations occur in the amount of lipid deposited in different parts of broiler chickens. Thus, the fat contents obtained for thigh muscle were higher than breast and drumstick muscles, which agree with Ikeme (1990) that the thigh muscles have numerous fat globules than other muscles.

Table 5 also shows the extent of oxidation measured as the concentration of malondialdehyde (MDA/kg muscle) of refrigerated meat from broiler chickens on the experimental treatments. There were significant differences ($p<0.001$) due to treatments and muscle type on the MDA concentration at days 1 and 6 of storage. The higher oxidative susceptibility observed in T4 and T11 is closely related to the high lipid content of the muscles due to high energy content of diets fed to birds on those treatments. Meat from birds on T4 had 0.77±0.11 mg MDA/kg at day 1 and 1.50±0.27 mg MDA/kg at day 6 while those on T11 had 0.79±0.14 mg MDA/kg at day 1 and 1.54±0.18 mg MDA/kg at day 6. At day 1 of storage, thigh muscle had the highest MDA concentration of 0.78±0.12 mg MDA/kg, followed by that of drumstick with 0.61±0.10 mg MDA/kg and the breast had the least 0.53±0.10 mg MDA/kg. This trend was maintained at day 6 of storage: thigh muscle had the highest 1.60±0.32 mg MDA/kg, followed by drumstick 1.22±0.22 mg MDA/kg and the least was for breast 1.01±0.23 mg MDA/kg ($p<0.05$). It was observed that MDA concentration in the meat significantly increased with increasing storage length in all the muscles irrespective of the experimental treatments. This agrees with earlier report of Onibi *et al.* (1998) that deteriorative changes due to oxidation continue to occur during refrigerated storage of meat. The MDA concentrations of breast and drumstick were significantly lower than those of thigh (Table 5) which indicated that the thigh muscle which had higher fat content was more susceptible to oxidation and hence the higher MDA concentration. This showed that the susceptibility of chicken parts to oxidation differ significantly from one part to another and it agrees with earlier reports Monahan *et al.* (1992) that the higher the quantity of lipid in meat, the higher the susceptibility of the meat to lipid oxidation.

CONCLUSION

The results of the study showed that broiler chickens could select a balanced diet from an option of feeds differing in energy and protein levels. It was also evident from the investigation that broiler chickens ate to meet their energy requirement. The high energy-low protein diets led to more fat deposition in the chickens, which made muscle more susceptible to lipid peroxidation. The protein content of broiler chicken diet should be given adequate attention when formulating feed so as to optimize production.

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