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Full Length Research Paper

High and low dietary energy and protein levels for broiler chickens

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This experiment was carried out to ascertain the effect of feeding combination of high and low calorie and protein on the performance and carcass values of broiler chickens. Four diets having four different combinations of calorie and protein namely; normal energy and normal protein (NENP), high energy and low protein (HELP), low energy and high protein (LEHP) and low energy and low protein (LELP) were fed to broiler chickens of Archer Abor breed for a period of 56 days. Results indicated a significantly ($p < 0.05$) reduced feed intake as the energy content of feed decreased with LELP having the lowest value while the final live weight were similar for birds on NENP and LELP. The dressing percentage was significantly ($p < 0.05$) better for birds fed NENP and had similar live weight as LELP. The study showed that low energy and low protein diets could be fed to broilers chicken as long as the energy:protein ratio is maintained which will be of advantage especially as the poultry industry is facing feed crisis as a result of use of cereals for biofuel.

Key words: Dietary energy, protein levels, performance, carcass, broiler chicken.

INTRODUCTION

Protein and energy are two important components of food that generates a lot of interest and challenges to nutriationists. They are determinants in the evaluation of the performance and production coefficients of farm animals. In poultry production, the regime of dietary protein and energy were established both in the tropics and temperate climates (Olomu and Offiong, 1980; Ojewola and Longe, 1999; NRC, 1994). The performance of broiler chicks were evaluated by Olomu and Offiong (1980) and reported that 23% crude protein (CP) with either 2800 or 3000 kcal/kg metabolizable energy (M.E.) was adequate as the requirement for starter broiler birds while Onwudike (1983) recommended 22% CP and 2900 kcal/kg M.E. Fetuga (1984) in his own report recommended a range of 23 - 24% CP and 2800 - 3000 kcal/kg M.E for starter broiler chicks and 19 - 21% CP with same energy level for the finisher phase. Ojewola and Longe (1999) reported that the feeding of 27% crude protein (which is considered high) in the broiler chicks' starter diet did not support good performance of the birds and had no advantage on lower values of 12 and 24% CP evaluated in the same experiment. However the dynamics of the scarcity of the raw materials for the feeding of livestock placed premium on the study of the actual required dietary nutrient in livestock feeding which must be well balanced for optimum performance and production. The introduction of synthetic or crystal amino acids and other agro by-products of fibrous nature with enzymes for enhanced utilization in monogastrics feeding to meet the dietary protein and energy needs have been worked upon (Morris et al., 1987; Aletor et al., 2000). The objective is to lower production cost as a result of the incessant scarcity of feed raw materials with consequential increase in price of animal feeds. However, most subsistent poultry farmers and the "Toll-millers" (quack animal feed manufacturers which many poultry farmers consult in our local situation in Nigeria) with inadequate knowledge of nutrition often substitute some of these costly energy and protein sources with any manner of fibrous bulk in poultry finished feed not minding the nature and characteristics of fibre in such feedstuffs. The implication of this may result in lower energy and in some cases lower protein in the diets. Advancement in breeding and changes in the climatic

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Table 1. Composition of the broiler starter and finisher experimental diets (%).

Ingredients (%)	Starter phase (0 - 4) weeks				Finisher phase (5 - 8) weeks			
	NENP	HELP	LEHP	LELP	NENP	HELP	LEHP	LELP
Maize	49.0	51.0	39.0	39.0	49.0	51.0	39.0	39.0
Maize offal	17.0	14.5	10.0	22.0	7.0	18.0	17.0	25.5
Soybean meal	16.0	15.0	28.0	8.0	23.0	13.0	26.0	8.0
Groundnut meal	10.0	10.0	11.0	23.0	11.0	10.0	8.0	19.0
Fish meal	2.0	2.5	4.0	1.0	3.5	1.0	2.0	0.5
Bone meal	3.0	2.0	4.0	4.0	2.0	2.0	4.0	4.0
Oyster shell	1.0	1.0	3.0	2.0	1.0	1.0	3.0	3.0
NaCl	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
*Vitamins and minerals premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Palm oil sludge	1.0	3.0	-	-	1.0	3.0	-	-
Determined analysis (%)								
Crude protein	23.0	19.96	24.94	20.83	20.14	18.45	22.17	18.87
M.E. ($MJKg^{-1}$)	2970	3155	2740	2775	2995	3145	2802.5	2745
Calorie: protein ratio	129.13:1	158.07:1	109.86:1	133.22:1	148.71:1	170.46:1	126.41:1	145.47:1

*Vitamins and mineral premix supplied the following per kg starter diet: Vitamin A: 1×10^7; Mn 80 g; vitamin K: 2,250 mg, Fe 20 g; Thiamine 1,750 mg; Cu 5 g; Riboflavin 5,000 mg; Iodine 1.2 g; Pyridoxine 2,750 mg; Se 200 mg; Niacin 2,750 mg; Co 200 mg; Pantothenic acid 7,500 mg; Zn 50 g; Folic acid 7, 500 mg. * Vitamins and premix supplied the following per kg finisher diet: Vitamin A 800 I.U.; D3 (1, 4731.C.U); Riboflavin 4.20 mg; Pantothenic acid 5.0 mg; Nicotinic acid 20.0 mg; Folic acid 0.5 mg; Choline 300 mg; Vitamin K, 2.0 mg; Vitamin B12, 0.01 mg; Vitamin E, 2.5I.U; Manganese, 56.0 mg; Iodine, 1.0 mg; Iron 20.0 mg; Copper 10.0 mg; Zinc 50.0 mg and Cobalt 1.25 mg.

and other environmental conditions dictates that constant evaluation of the nutrient requirements of the birds is carried out. It is against this backdrop that investigation is conducted on the crude protein and energy dietary needs in broiler chicken taking cognizance of no advantageous benefits of feeding high fibre diets to poultry especially broilers. This study therefore evaluated the performance of broiler chicken when fed diets containing different combinations of extremes of energy and protein.

MATERIALS AND METHODS

Preparation of experimental diets

Four different types of broiler chicken starter and finisher diets were formulated (Table 1) to contain low energy and high crude protein (LEHP), high energy and low crude protein (HELP), normal energy and normal crude protein (NENP) and low energy and low crude protein (LELP). Palm oil sludge obtained from the oil palm processing unit of the Teaching and Research, University of Ado-Ekiti Farm was added as source of energy in NENP and HELP diets.

Animal management and experimental design

A total of three hundred day old broiler chicks of Archer Arbor breed were divided into four groups constituting the treatments, namely the dietary levels of energy and protein in the starter feed. Four combinations of the energy and protein dietary levels designated as normal energy and normal protein (NENP), high energy and low protein (HELP), low energy and high protein (LEHP) and low energy and low protein (LELP) were arranged in a completely randomized design feeding trial. The experiment was carried out in the brooder unit of the University of Ado-Ekiti Teaching and Research Farm. Each group or treatment had three replicates comprising 25 broiler chicks in deep litter pens of 3 × 6 m dimension randomly located in the brooder house.

The birds were orally administered antibiotics, fortified with vitamins as anti-stress in drinking water on arrival for seven days. Heat was supplied for brooding using a combination of 200 W electric bulb in each pen and a large size charcoal burner in a brooder house well covered with polythene sheet. All other required medication schedule and routine management practices were carried out during the trial that lasted 56 days. The duration of the trial was divided into two phases namely the starter phase that lasted 28 days (0 - 4 weeks) and the finisher phase (5 - 8 weeks). Experimental feed and water were offered *ad-libitum.*

Data collection

Performance indices

The performance characteristics monitored were feed intake, body weight gain, feed conversion ratio (FCR) and protein efficiency ratio (PER). These were measured during the starter and the finisher phases.

Carcass measurements and blood sample collection

Three birds were randomly selected from each replicate bi-weekly

Table 2. Performance characteristics of broilers chicken fed four regimes of energy and protein separately at the starter and finisher phases.

Parameter	Starter phase 0 – 4 weeks				Finisher phase 5 – 8 weeks			
	NENP	HELP	LEHP	LELP	NENP	HELP	LEHP	LELP
Feed intake (g)	62.4 ^{ab} ±8.2	67.2^{a}±6.3	60.1 ^{b}±2.5	58.2^{b}±2.9	123 ^{b}±9.1	128 ^{a}±5.0	123^{b}±7.1	126 ^{b}±6.4
Live weight (g)	640 ^{ab}±12.3	612 ^{ab}±8.4	506 ^{b}±11.0	687 ^{a}±10.3	1635^{a}±9.3	1317 ^{ab}±11.4	1282^{b}±8.3	1476 ^{ab}±12.1
Body weight gain (g)	21.6 ^{a}±2.0	20.6 ^{a}±0.2	16.8 ^{c}±0.1	23.3 ^{b}±1.0	35.53 ^{a}±1.0	25.2 ^{b}±0.2	27.7 ^{b}±0.8	28.2 ^{b}±0.4
*FCR	2.89 ^{b}±0.0	3.26 ^{b}±0.1	3.56 ^{a}±0.2	2.51 ^{b}±0.1	3.45 ^{c}±0.1	5.09 ^{a}±0.9	4.45 ^{b}±0.8	4.46 ^{b}±0.2
**PER	1.53 ^{a}±0.2	1.53 ^{a}±0.0	1.13 ^{b}±0.3	1.91^{a}±0.1	1.43 ^{a}±0.2	1.06 ^{b}±0.1	1.01 ^{ab}±0.5	1.18 ^{a}±0.0

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$); *FCR = Feed conversion ratio; ** PER = Protein efficiency ratio.

to monitor the dressing percentage, head, neck, wings, back, thigh, drum stick, shank and some internal organs such as liver, kidney, spleen, heart, lungs, gizzard, pancrease, crop, small and large intestine. The birds were fasted overnight to clear the gut of digesta to a reasonable extent but allowed access to water. The live weights were measured the following morning and later slaughtered by decapitating the head. They were thoroughly bled and the carcass defeathered, cleaned with water and properly drained. Blood samples were collected into well labelled heparinized bottle for some haematology and serum enzymes analysis. They are packed cell volume (PCV), red blood cell (RBC), haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC). Aspartate amino transaminase (AST) (EC 2.6.1.1.1) and alanine amino transaminase (ALT) (EC 2.6.1.1.2) were also determined. The eviscerated weight was measured to calculate the dressing percentage as the percent of dressed carcass weight to live weight of the bird. The internal organs listed above were carefully removed and weighed. The cut parts and the internal organs were monitored bi-weekly and were expressed as the percentage of dressed weight while the length of the small and large intestine were also measured and weighed after the removal of gut contents.

Digestibility trial

At the 21st and 49th day of the experiment (representing the beginning of the 4th and 8th week respectively), three birds each from each replicate were selected randomly into corresponding compartment of the metabolism cage for digestibility trial. The feed intakes during the periods were noted and the faeces collected on aluminum foil on daily basis, dried and later pooled. They were weighed wet and samples from each replicates were taken and dried in Gallenkamp oven at 65°C for 72 h. The dried samples were kept for proximate composition determination.

Chemical analysis and statistical tool

The experimental feeds and the faecal samples were analyzed as described by AOAC (2005). Serum AST and ALT were determined by the method of Reitman and Frankel (1957), while urea was estimated by the diacetylmonoxine method. The MCHC, MCH and MCV were calculated as described by Sastry (2004). All the data collected were analyzed by ANOVA using SAS (1992) and means separated by the application of Duncan's multiple range test. The values of data were expressed as mean±SD.

RESULTS

The result of the performance indices of the experimental birds for the starter and finisher phases are presented in Table 2. The feed intake of the birds fed HELP diet was significantly highest ($p < 0.05$) at the starter phase while those on LELP had the lowest. The final live weight (FLW) was highest ($p < 0.05$) for broilers birds fed with NENP and lowest for LEHP. The body gain (BWG) also followed similar trend as FLW. Feed conversion ratio (FCR) was significantly better ($p < 0.05$) in NENP, a trend also exhibited by the protein efficiency ratio (PER). Nitrogen and fat digestibility values were similar and highest ($p < 0.05$) for birds fed NENP and lowest for those on LEHP at the 4th week. This trend was repeated at the 8th week. While the fibre and dry matter digestibility values were not affected ($p > 0.05$) by the energy and protein dietary levels at the 4th week, the dry matter was significantly higher ($p < 0.05$) for birds fed HELP and NENP but lowest LEHP (Table 3).

The values of haematological indices and the serum enzymes monitored are shown in Tables 4 and 5. The PCV, RBC, Hb, MCV, MCH, MCHC, AST and ALT were consistently highest ($p < 0.05$) for the birds on HELP at the 4th and 8th week.

The feed intake had a similar pattern during the finisher phase when compared with the starter phase. Broiler chickens fed HELP diet had the highest ($p < 0.05$) feed intake while LELP had the lowest. The FLW and the BWG values at the finisher phase had similar trend (Table 2). The FCR was better for birds on NENP but lowest for LEHP. There was a repeat of this trend for values obtained for the PER (Table 2). During the 0 - 8 weeks of age, the FI, WI, FLW, BDG, FCR and PER of the birds had values that were almost similar to the observations made at the starter and finisher phases (Table 6).

Carcass measurements

The carcass characteristics of the experimental birds are shown in Tables 7 to 10. The live weight at the 2nd week of age was significantly higher ($p < 0.05$) and similar for broilers fed HELP and NENP diets but those on LEHP had the lowest value. The eviscerated weight was highest ($p < 0.05$) for broilers fed with NENP and HELP diets

Table 3a. Nutrient digestibility of broilers fed four regimes of energy and protein at 4 weeks of age (%).

Parameter	NENP	HELP	LEHP	LELP
Nitrogen	77.5 ^{a} ±0.2	78.0 ^{a} ±0.1	64.0 ^{c}±0.3	69.7 ^{b}±0.2
Fat	70.2 ^{a} ±0.7	69.4^{a} ±0.5	64.6 ^{b}±0.2	68.8 ^{a} ±0.5
Fibre	61.1±0.3	60.4±0.11	59.9±0.2	59.6±0.1
Dry matter	55.3±0.1	57.9±0.1	53.6±0.3	55.2±0.4

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

Table 3b. Nutrient digestibility of broilers fed four regimes of energy and protein at 8 weeks of age (%).

Parameter	NENP	HELP	LEHP	LELP
Nitrogen	61.2 ^{a} ±0.4	62.0 ^{a} ±0.9	52.0^{c}±0.21	54.2 ^{b}±0.2
Fat	68.4 ^{a} ±0.1	68.2 ^{a} ±0.3	60.7 ^{b}±0.2	69.1 ^{a} ±0.7
Fibre	70.3±0.8	69.1±0.21	68.5±0.1	69.5±0.3
Dry matter	67.7^{b}±0.2	69.3^{a} ±0.1	60.3^{c}±0.1	65.8^{b}±0.3

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

Table 4. Some haematological indices of broilers fed four regimes of energy and protein at 4 weeks of age.

Parameter	NENP	HELP	LEHP	LELP
PCV (%)	32.1 ^{a} ±1.0	33.1 ^{a} ±0.3	31.1 ^{ab} ±0.9	31.8 ^{b} ±2.0
RBC (10^{6} mm)	2.70 ^{b} ±0.2	2.72 ^{a} ±0.3	2.44 ^{d} ±0.8	2.63 ^{c} ±0.2
Hb (g/100 g)	2.49^{ab} ±0.0	2.50 ^{a} ±0.0	2.43 ^{c} ±0.0	2.48 ^{b} ±0.3
MCHC (%)	8.01 ^{a} ±0.01	8.21 ^{a} ±0.2	7.61 ^{b} ±0.4	7.83 ^{a} ±0.5
MCH (pg)	9.37 ^{a} ±0.03	9.50 ^{a} ±0.1	8.21 ^{b} ±0.07	8.73 ^{ab} ±0.23
MCV (µm^{3})	125^{a}±3.4	125^{a}±0.9	124^{c}±4.1	124^{b}±0.0
Urea (mg/dl)	14.6^{c} ±0.1	13.9^{c} ±0.0	18.3^{a} ±0.3	15.0^{b} ±0.8
AST (iµ/L)	45.3^{b} ±1.9	44.8^{c} ±2.2	48.6^{a}± 1.2	48.52^{a} ± 3.61
ALT (iµ/L)	58.4^{c} ±1.2	55.2^{c} ±1.1	60.2^{a} ±2.1	59.4^{b} ±0.9

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

Table 5. Some haematological indices of broilers fed four regimes of energy and protein at 8 weeks of age.

Parameter	NENP	HELP	LPHE	LELP
PCV (%)	31.7^{a}±3.0	32.8^{a} ±1.0	29.3^{b}±0.9	30.0^{b} ±2.5
RBC (10^{6} mm)	2.6^{b}±0.1	2.77^{a} ±0.2	2.61^{d}±0.0	2.70^{c}±0.4
Hb (g/100 g)	2.71^{a} ±0.9	2.69^{ab} ±0.5	2.50^{d}±0.1	2.60^{c}±0.0
MCHC (%)	9.82^{a} ±0.3	9.53^{a} ±0.2	8.32^{b}±0.2	8.72^{ab}±0.5
MCH (pg)	9.71^{a}±0.8	9.99^{a}±0.1	9.01^{b}±0.0	9.52^{ab}±0.2
MCV (µm^{3})	128^{a}±4.2	130^{a}±3.5	110^{c}±2.3	120^{b} ±2.9
Urea (mg/dl)	17.4 ^{c}±0.0	17.2 ^{c}±0.2	21.7^{a}±0.7	19.3^{b}±0.0
AST (iµ/L)	51.8^{c} ±0.9	52.0^{c} ±1.6	59.0^{a}±3.0	54.9^{b} ±2.0
ALT (iµ/L)	60.1^{c} ±1.2	60.9^{c}±3.4	69.1^{a} ±2.2	65.0^{b} ±0.1

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

while LELP and LEHP had the lowest. The head expressed as percent eviscerated weight followed similar trend as the live weight. Neck, wings, back, breast, thigh and the drum stick were all significantly influenced ($p < 0.05$) and followed the same trend. HELP and NENP had the highest but similar values whereas LEHP had the

Table 6. Performance characteristics of broilers chicken fed four regimes of energy and protein at the starter and finisher phases combined (0 - 8 weeks).

Parameter	NENP	HELP	LEHP	LELP
Feed intake (g)	$100^{b} \pm 2.10$	$108^{a} \pm 1.18$	$102^{b} \pm 2.20$	$90^{c} \pm 0.90$
Final Live weight (g)	$1635^{a} \pm 9.3$	$1317^{ab} \pm 11.4$	$1282^{b} \pm 8.3$	$1476^{ab} \pm 12.1$
Body weight gain (g)	$28.6^{a} \pm 3.4$	$22.9^{ab} \pm 1.5$	$22.3^{b} \pm 2.7$	$25.7^{ab} \pm 2.2$
*FCR	3.51^{b}	4.70^{a}	4.58^{a}	3.51^{b}
**PER	1.6^{a}	1.6^{a}	1.3^{b}	1.6^{a}

$^{a, b, c}$ Means on the same row with different superscripts differ significantly($p < 0.05$); *FCR = Feed conversion ratio; ** PER = Protein efficiency ratio.

Table 7. Carcass and internal organs of broilers fed four regimes of energy and protein at 2 weeks of age.

Parameter	NENP	HELP	LEHP	LELP
Live weight (g)	$237^{a} \pm 1.3$	$238^{a} \pm 1.1$	$181^{b} \pm 2.9$	$224^{a} \pm 1.8$
Dressed weight (%)	$91.1^{a} \pm 0.34$	$90.5^{ab} \pm 0.5$	$89.7^{bc} \pm 1.01$	$89.4^{c} \pm 0.09$
Head (%)	$4.40^{ab} \pm 0.01$	$4.54^{a} \pm 0.12$	$4.03^{b} \pm 0.1$	$4.37^{ab} \pm 0.1$
Neck (%)	$4.97^{a} \pm 0.2$	$4.95^{a} \pm 0.1$	$3.78^{b} \pm 0.3$	$4.65^{ab} \pm 0.2$
Wing (%)	$7.63^{a} \pm 0.2$	$7.37^{ab} \pm 0.1$	$7.04^{b} \pm 0.0$	$7.26^{ab} \pm 0.1$
Back (%)	$14.9^{a} \pm 0.3$	$13.9^{ab} \pm 0.0$	$10.8^{c} \pm 0.2$	$12.2^{bc} \pm 0.3$
Breast (%)	$17.5^{a} \pm 0.2$	$16.1^{a} \pm 0.5$	$15.4^{b} \pm 0.2$	$16.1^{a} \pm 0.0$
Thigh (%)	$15.2^{a} \pm 0.2$	$15.4^{a} \pm 0.1$	$11.9^{b} \pm 0.1$	$14.1^{a} \pm 0.1$
Drum stick (%)	$12.1^{a} \pm 0.0$	$12.29^{a} \pm 0.0$	$11.7^{b} \pm 0.1$	$12.2^{a} \pm 0.0$
Shank (%)	$4.79^{c} \pm 2.1$	$4.88^{bc} \pm 2.0$	$5.70^{a} \pm 1.9$	$5.09^{a} \pm 2.0$
Body fat (%)	$3.71^{b} \pm 0.1$	$4.37^{a} \pm 0.0$	$3.60^{b} \pm 0.0$	$2.27^{c} \pm 0.0$
Liver (%)	3.33±0.1	3.09±0.0	3.18±0.0	2.67±0.1
Kidney (%)	$1.93^{a} \pm 0.2$	$1.88^{ab} \pm 0.1$	$1.78^{a} \pm 0.1$	$1.95^{a} \pm 0.1$
Pancrease (%)	0.39±0.1	0.40±0.0	0.39±0.1	0.41±0.0
Spleen (%)	$0.06^{b} \pm 0.0$	$0.07^{b} \pm 0.0$	$0.07^{b} \pm 0.0$	$0.09^{a} \pm 0.1$
Heart (%)	0.80±0.1	0.74±0.1	0.83±0.1	0.92±0.2
Lung (%)	0.71±0.0	0.61±0.0	0.67±0.1	0.72±0.0
Total intestine (%)	19.7±1.0	19.4±1.3	18.5±0.6	18.29±0.8
Small intestine (%)	$17.4^{a} \pm 0.9$	$17.8^{a} \pm 0.2$	$16.2^{b} \pm 0.1$	$16.0^{b} \pm 0.1$
Large intestine (%)	2.47±0.3	2.39±0.5	1.90±0.1	2.40±0.2
Small intestine (cm)	90.7±1.5	105±1.9	73.6±2.0	91.7±2.0
Large intestine (cm)	11.5±0.2	18.0±0.4	12.4±0.3	12.0±0.1
Gizzard (%)	0.07±0.03	0.07±0.01	0.074±0.08	0.071±0.11
Crop (%)	$1.09^{a} \pm 0.1$	$1.02^{a} \pm 0.0$	$0.73^{b} \pm 0.1$	$0.85^{ab} \pm 0.1$

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

lowest for the listed cut parts. Broiler birds fed LELP had the highest ($p < 0.05$) value for spleen while the other treatments showed similar values.

The shank was lowest ($p < 0.05$) for broilers fed with NENP. The body fat was significantly highest ($p < 0.05$) for birds fed HELP. All other internal organs namely; the liver, heart, lung, total intestine, length of small and large intestine, gizzard and the pancrease were not significantly affected ($p > 0.05$).

At the 4th week of age, the live weight, neck, wings, breast, shank, body fat, liver and the kidney were all highest ($p < 0.05$) and similar for NENP and HELP and this trend was followed at the 6th and 8th weeks except for the lung, large intestine, length of small intestine and the crop. The nitrogen digestibility was higher ($p < 0.05$) and similar for NENP and HELP. Fat digestibility was significantly lower ($p < 0.05$) in birds fed LEHP when compared to those on NENP, HELP and LELP. This trend was repeated at the 4th and 8th week (Tables 3a and b).

Table 8. Carcass and internal organs of broilers fed four regimes of energy and protein at 4 weeks of age.

Parameter	NENP	HELP	LEHP	LELP
Live weight (g)	640 ^{ab} ± 12.31	612 ^{ab} ± 8.39	506 ^{b} ± 11.03	687 ^{a} ± 10.28
Dressed weight (%)	70.1 ±9.0	71.2 ±1.0	69.8 ±8.6	71.2 ±1.2
Head (%)	4.22±1.3	4.50±0.9	4.15±1.0	4.63±1.1
Neck (%)	4.92 ^{a} ±0.2	4.75 ^{a} ±1.2	3.78 ^{b} ±1.2	4.65 ^{ab} ±2.2
Wing (%)	6.16^{a} ±0.4	4.72 ^{a} ±0.7	2.72 ^{b} ±0.9	4.55 ^{a} ±0.2
Back (%)	15.6±1.9	13.2±1.0	12.3±1.1	16.2±1.7
Breast (%)	16.9^{a} ±1.1	17.4^{a} ±0.9	14.2^{b} ±1.0	17.5^{a} ±1.4
Thigh (%)	15.6±1.0	13.5±1.2	11.2±0.9	16.3±1.2
Drum stick (%)	14.2±0.3	15.2±1.0	12.4±1.1	15.5±1.3
Shank (%)	4.31^{ab} ±1.2	3.36^{b} ±1.3	4.72^{ab} ±0.9	5.08 ^{a} ±0.8
Body fat (%)	5.89 ^{ab}±0.0	6.31^{a}± 0.9	5.07 ^{b}±1.0	3.22 ^{c}±1.1
Liver (%)	2.43^{ab}±0.1	2.51^{a}±0.1	2.30^{b}±0.9	2.54^{a}±1.0
Kidney (%)	2.29^{ab}±0.8	2.20^{ab}±1.1	1.92^{b}±0.0	2.19^{a}±0.9
Pancrease (%)	0.32±0.1	0.33±0.08	0.29±0.04	0.33±0.0
Spleen (%)	0.11±0.0	0.12±0.0	0.09±0.0	0.15±0.0
Heart (%)	0.9±0.1	0.91±0.0	0.9±0.1	0.67±0.0
Lung (%)	0.9±0.0	0.8±0.0	0.71±0.0	0.68±0.0
Total intestine (%)	13.2±1.3	14.2±1.1	14.11±1.1	13.5±1.2
Small intestine (%)	10.9±0.8	8.17±0.5	7.32±0.1	7.96±0.1
Large Intestine (%)	2.61±0.1	5.86±0.0	4.03±0.0	5.41±0.2
Small intestine (cm)	119±12.0	126±9.4	118±8.5	117±7.0
Large intestine (cm)	6.20±0.0	5.55±0.1	5.00±0.4	6.82±0.7
Gizzard (%)	5.40±0.0	5.15±0.0	5.27±0.3	4.91±0.5
Crop (%)	0.76±0.0	1.03±0.0	0.99±0.0	0.79±0.1

$^{a, b, c}$ Means on the same row with different superscripts differ significantly ($p < 0.05$).

DISCUSSION

The feed intake of the experimental birds at the starter and finisher phases were influenced by the dietary levels of energy and protein. The feed intake was lower for birds fed diets with low energy-high protein combination (LEHP) and low energy-low protein (LELP). The LELP diets contained relatively high level of maize offal in the feed. The voluntary feed intake of birds or monogastrics have been established to be a function of dietary fibre characteristics (Sundu et al., 2005a; Fatufe et al., 2007). It is known that replacing maize with wheat offal above 50% in broiler chickens reduce feed intake (NAPRI, 1985). Therefore, the dietary level of inclusion of wheat offal may have resulted into gut filling in the birds hence the observed decline in the feed intake.

The calorie : protein ratio of diets had been found to play a prominent role in the performance of broiler chicken (NRC, 1994; Aftab et al., 2006). A range of calorie: protein ratio of 132 to 155:1 for broiler chicken was suggested which could be lowered to between 155 and 195 or 10% of the recommended levels when broilers are fed low crude protein concentration (Aftab et al., 2006). In this study, the calorie: protein values of LELP at the starter and finisher phases met the recommended values except for LEHP (109.86:1 and 126.41:1 for the corresponding phases). This perhaps explains the poor performance of broiler chickens fed with LEHP diet. Quite a lot of the excess amino acids that may have been available in the diet might have been metabolically utilized and hence “wasted” (Musharaf and Latshaw, 1999). Therefore, the indiscriminate use of poor quality protein sources as bulk ingredient by farmers or feed manufacturers especially in the period of scarcity may be counter productive.

Some of the carcass compositions of the broiler chicken (Tables 7 to 10) were affected by the different dietary levels of the energy and protein. The live weight of the birds fed LEHP consistently recorded the lowest value throughout the trial. These results indicate that excess high protein content in broiler feed is of no advantage. Excess protein in the diet where the energy is low has been reported to be dissipated as heat increment after consumption usually in the order of protein > carbohydrate > fat (Musharaf and Latshaw, 1999; Gous and Morris, 2005). This means there is a threshold above and below which the protein concentration as a nutrient is not justifiable (Si et al., 2001) hence no positive result is expected in terms of growth and other performance indices. The cut parts percentages showed linear

Table 9. Carcass and internal organs of broilers fed four regimes of energy and protein at 6 week of age.

Parameter	NENP	HELP	LEHP	LELP
Live weight (g)	1143^{a} ± 12.1	1150^{a} ± 8.6	937^{b} ± 10.2	1117^{a} ± 10.9
Dressed weight	72.1±4.8	75.3±3.5	73.08±2.3	71.8±2
Head (%)	4.75^{a}±3.0	4.65^{ab}±2.3	4.44^{b}±2.1	4.76^{a}±3.1
Neck (%)	4.64^{a}±0.2	4.55^{ab}±1.2	4.16^{b}±0.2	4.47^{ab}±0.1
Wing (%)	9.53^{a}±0.3	9.60^{a}±0.05	8.79^{b}±0.62	9.71^{a}±0.22
Back (%)	15.5^{ab}±2.1	16.41^{a}±2.0	15.18^{b}±1.1	16.1^{ab}±0.9
Breast (%)	6.36^{a}±0.2	5.98^{ab}±0.1	5.45^{b}±0.0	4.95^{c}±0.6
Thigh (%)	11.9^{b}±0.1	11.6^{b}±1.2	13.6^{a}±0.2	10.0^{c}±0.0
Drum stick (%)	10.0^{b}±0.1	9.54^{b}±0.2	11.4^{a}±0.8	10.4^{ab}±0.6
Shank (%)	3.83^{b}±0.1	4.05^{ab}±0.7	4.62^{a}±0.0	4.06^{ab}±0.3
Body fat (%)	5.98^{ab}±0.1	6.36^{a}± 0.2	5.45^{b}±0.0	4.95^{c}±0.6
Liver (%)	2.56^{a}±0.1	2.27^{ab}±0.1	2.09^{b}±0.2	2.40^{ab}±0.1
Kidney (%)	1.32±0.4	1.83±0.3	1.06±0.2	1.76±0.6
Pancrease (%)	0.16^{b}±0.0	0.14^{b}±0.1	0.25^{a}±0.0	0.14^{b}±0.0
Spleen (%)	0.14±0.0	0.11±0.0	0.14±0.0	0.12±0.1
Heart (%)	0.46±0.1	0.41±0.0	0.47±0.0	0.44±0.0
Lung (%)	0.49^{a}±0.0	0.44^{b}±0.0	0.45^{ab}±0.0	0.38^{c}±0.0
Total intestine (%)	10.0±0.7	10.29±0.9	11.52±1.0	10.6±0.7
Small intestine (%)	8.48±0.5	8.62±0.0	7.86±0.3	8.08±0.4
Large intestine (%)	1.21^{b}±0.0	1.15^{b}±0.1	1.78^{a}±0.1	1.14^{b}±0.1
Small intestine (cm)	138^{bc}±4.1	160^{a}±7.0	126^{c}±3.0	157^{ab}±5.0
Large intestine (cm)	7.02±0.21	8.07±0.14	7.50±0.23	7.44±0.11
Gizzard (%)	2.56 ±0.1	2.83±0.0	2.73±0.2	2.26±0.1
Crop (%)	0.36^{b}±0.0	0.70^{a}± 0.0	0.31^{b}±0.0	0.30^{b}±0.1

a, b, c Means on the same row with different superscripts differ significantly ($p < 0.05$).

Table 10. Carcass and internal organs of broilers fed four regimes of energy and protein at 8 weeks of age.

Parameter	NENP	HELP	LEHP	LELP
Live weight (g)	1635^{a}±9.2	1316^{ab}±11.4	1282^{b}±8.27	1476^{ab}±12.1
Dressed weight (%)	70.6^{a}±1.6	69.7^{b}±0.0	68.2^{b}±1.0	66.2^{c}±0.9
Head	2.63±0.0	3.72±0.1	3.91±0.2	3.04±0.3
Neck	2.96±0.0	2.24±0.0	2.23±0.0	2.17±0.1
Wing	8.26^{a}±1.3	9.27^{b}±1.1	9.67^{ab}±1.3	8.69^{ab}±1.2
Back	14.5^{a}±5.6	13.1^{b}±4.3	13.4^{b}±2.2	14.4^{ab}±4.8
Breast	7.36^{a}±0.2	6.98^{ab}±0.1	6.45^{b}±0.0	5.95^{c}±0.6
Thigh	12.6±3.4	14.9±2.2	15.0±2.0	13.6±0.1
Drum stick	15.3^{a}±0.1	13.3^{b}±1.0	13.6^{b}±0.9	9.07^{c}±0.6
Shank	4.15±0.2	4.76±0.1	4.79±0.8	4.74±0.2
Body fat (%)	9.07^{b}± 0.3	9.95^{a}±0.7	9.03^{ab}±0.1	8.15^{c}±0.0
Liver (%)	3.10±0.1	2.62±0.0	2.75±0.1	2.41±0.0
Kidney (%)	1.37^{a}±0.1	1.18^{ab}±0.1	1.09^{b}±0.2	1.31^{c}±0.1
Pancrease (%)	0.23±0.0	0.22±0.0	0.23±0.1	0.24±0.0
Spleen (%)	0.12^{b}±0.0	0.14^{b}±0.0	0.18^{a}±0.1	0.11^{b}±0.0
Heart (%)	0.55±0.0	0.61±0.0	0.55±0.0	0.57±0.1
Lung (%)	0.51±0.0	0.56±0.0	0.52±0.0	0.57±0.0
Total intestine (%)	11.2±0.3	12.7±0.4	12.6±0.3	11.6±0.1
Small intestine (%)	9.54±0.7	9.80±0.2	8.88±0.1	9.48±0.6
Large intestine (%)	1.58±0.3	2.08±0.0	1.67±0.1	1.17±0.4

Table 7. Cont'd.

Small intestine (cm)	$173^{a} \pm 13.1$	$147^{ab} \pm 4.0$	$123^{a} \pm 5.0$	$167^{a} \pm 8.0$
Large intestine (cm)	13.43±1.2	17.1±2.1	18.7±3.4	14.8±1.1
Gizzard (%)	$2.65^{b} \pm 0.1$	$2.90^{ab} \pm 0.0$	$3.16^{a} \pm 0.3$	$2.65^{b} \pm 0.0$
Crop (%)	$0.52^{a} \pm 0.0$	$0.69^{a} \pm 0.1$	$0.62^{ab} \pm 0.0$	$0.39^{b} \pm 0.0$

[a, b, c] Means on the same row with different superscripts differ significantly ($p < 0.05$).

increase for birds fed HELP and NENP because the increase in energy content of the experimental diets indicated to a large extent adequacy of supply of other nutrients even at the minimal dietary level which agrees with the report of Gous et al. (1990). Hence formulation of animal feed must take into consideration the nutrient density with energy as the prime factor of the particular feed to facilitate production objectives. Broiler chickens with high dietary protein level (LEHP) gave a leaner carcass (Tables 7, 8, 9 and 10) as shown in the values of dressed or eviscerated weight expressed as percent live weight and other cut parts (Buyse et al., 1992; Kita et al., 1993; Nieto et al., 1997; Collin et al., 2003). The body fat deposition significantly increased in birds fed high and normal energy inclusion in the diets resulting into a high calorie: protein ratio which agrees with the report of Swenen et al. (2006). The addition of palm oil in the diet obviously must have increased the level of the unsaturated fatty acid (even though this was not evaluated) thereby facilitating better utilization of the diet for enhanced body growth and fat deposition. This report is at variance with the work of Sizemore and Siegel (1993) who reported no effect of dietary fat concentration on body fat in broilers at constant calorie: protein ratio. Though the percent total intestine, small intestine and large intestine and their length were not affected by the dietary levels of energy and protein, the crop was different. It consistently had a higher value at the second week of age of the birds during the trial. This might be due to the rate of intake by the young chicks with a high post - hatch propensity for feed to meet high growth rate (Sklan and Noy, 2003; Wijtten et al., 2004). The high feed intake recorded by broilers fed HELP diet both at starter and finisher phases no doubt must have influenced the holding capacity of the crop over time resulting into higher cell mass and volume. Nitrogen and fat digestibility was highest in the NENP and HELP both at the 4th and 8th weeks but lowest in LEHP. The availability of energy in the diets mighty be responsible for their adequate utilization by the birds on these diets.

The haematological indices were generally affected especially between the control and birds on LELP while the serum enzymes activities were best in the control. As much as this indicated a better utilization of the control diet, it did not manifest any anaemic condition in birds fed other diets especially LELP. It can be concluded that with adequate balance of calorie and protein low energy and low protein combination diet could be fed broiler chickens for a good performance.

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