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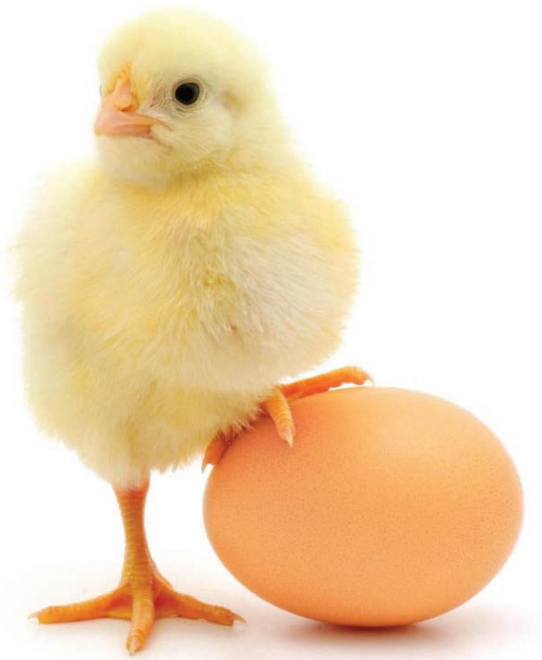

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Research Article
Response of Pullet Chicks on Energy and Protein Ratios in Yola, Adamawa State, Nigeria

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Abstract
Objective: This study aimed to determine the appropriate ratio of energy and protein to maintain optimal growth of pullet chicks that will lead to optimum layer performance. **Materials and Methods:** A total of 270 day-old chicks (Isa Brown), were distributed in a completely randomized design in a 3×3 factorial arrangement forming 9 treatments with 30 birds per treatment. Each treatment was replicated three times. The chicks were fed diets containing 3 energy (2500, 2700 and 2900 ME (kcal kg^{-1}) and 3 crude protein (CP) levels (18, 20 and 22%) from 2-7 weeks of age. **Results:** Feed intake of chicks increased with increase in E:P-ratio (from 124.97-139.60 g bird^{-1} week^{-1}) while at 20 and 22% CP, feed intake of chicks decreased with increase in E:P-ratio. Body weight gain increased with increase in protein levels at the three energy levels. Birds fed on 2500, 2700 and 2900 ME kcal kg^{-1} showed increased body weight gain (281.17-524.17 g, 282.50-325.83 g and 362.00-492.33 g, respectively) with increment in CP levels from 18, 20 and 22%. Similarly, lower feed conversion ratio was observed in birds fed 18, 20 and 22% CP. **Conclusion:** The results of this study showed that starter chicks fed low energy-high protein diet (2500 ME (kcal kg^{-1}) at 22% CP level grew significantly faster and had lower cost kg^{-1} gain (₦ 194.25) as compared to other combinations (₦ 204.15 to ₦ 234.57), therefore it is recommended that, starter chicks could be fed on 2500 ME (kcal kg^{-1}) diet at 22% crude protein.

Key words: Body weight gain, chicks diet, feed conversion ratio, feed intake, protein, water intake

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In most parts of the world, protein is the major nutrient deficiency[1]. This is more visible in developing countries where animal protein has been insufficient to meet the demands of the rapidly growing population of about 5.814 billion[2]. FAO[3] reported that consumption of poultry products in developing countries has increased by 5.8% per annum, over the last decade and this is faster than the human population growth, and has created a great increase in demand. Ojo[4] reported that animal protein consumption in Nigeria is 5 g caput^{-1} day^{-1} which is below the FAO[3] recommended level of 35 g caput^{-1} day^{-1}. In USA, Denmark and UK, it is 64, 57 and 54 g, respectively[5]. Nutrition is perhaps the most important consideration in livestock management. Inadequate supply of feeds, nutritionally imbalanced rations, adulterated ingredients or stale feeds are some of the factors responsible for low productivity of livestock in the tropics[6]. In poultry nutrition, energy is used for the provision of body heat, maintenance, growth and production[7], while protein is a vital nutrient for poultry. In virtue of its amino acid constituents, protein play a significant role in growth, egg production, immunity, adaptation to the environment and in many other biological functions. Dietary energy and protein is mainly associated with the production cost of meat. While the importance of energy cannot be over-emphasized, dietary protein are essential for normal growth and reproduction of animal. The cost of protein and energy components used in commercial poultry diets make up approximately 90% of total feed cost[8]. In considering any material as component of feeds, its nutritive values, availability, price and ease of processing should be considered. Many energy and protein sources of both plant and animal origins have been used by researchers with the view of minimizing cost of production and improve or at least maintaining performance. Pond *et al.*[9] stated that feed accounts for about 60-80% of the total costs of poultry production out of which energy constitute 40-60% and protein 30-40%. Aremu *et al.*[10] stated that the provisions of energy and protein in the diet account for 90% of the total cost of the ration. With that in mind, there is need for judicious use and application of these resources to reduce cost of production and maximize profit. Therefore, maximizing the efficiency of energy and protein (amino acids) utilization is very important for the reduction of feed cost, ultimate profit and maximization of lean meat production with minimum intake of diet. The concept of energy: protein ratio (EP ratio) or calorie: protein ratio (CP ratio) is very important in poultry feeding. It ensures adequate protein intake at all possible dietary metabolisable energy levels. This stud was conducted to makes possible formulation of high energy diets for maximum growth rate and feed conversion efficiency of chickens.

MATERIALS AND METHODS

The research was conducted at the University Poultry Research Farm, Modibbo Adama University Yola, Adamawa State, Nigeria. Yola is Located between latitude 7° and 11°N of the equator and longitude11° and 14°E of the Greenwich Meridian with altitude of 185.9 m above sea level and lies within the Northern Guinea Savannah Zone of Nigeria. Maximum temperature in the state reaches 40°C particularly in April while minimum temperature is 18°C between December and January. Mean monthly temperature in the state ranges from 26.7°C in the South to 27.8°C in the Northeast part of the state[11].

Experimental animals, treatments, design and management: A total of 270 day-old chicks (Isa Brown) were purchased from ECWA Farm, Jos with an average body weight of 31.25 g on arrival. The chicks were provided with heat during the first two weeks of age using kerosene-heated stoves and 200W electric bulbs. The chicks were randomly allocated to nine treatments, replicated three times in a Complete Randomised Block Design involving 3×3 factorial arrangement, after two weeks of brooding. Each replicate of ten chicks were reared on concrete floor, measuring 1.2×2.0 m covered with wood shavings of 5 cm thick as bedding material. The low-medium and high-energy diets, contained 18% CP (low protein), 20% CP (medium protein) and 22% CP (high protein), respectively. The dietary metabolisable energy (ME) levels were 2500 kcal kg^{-1} diet (low energy), 2700 kcal kg^{-1} diet (medium energy) and 2900 kcal kg^{-1} diet (high energy). The three energy levels and three protein levels were used to produce the nine treatment diets namely: Low energy-low protein (LELP), Low energy-Medium protein (LEMP), Low energy-high protein (LEHP), Medium energy-low protein (MELP), Medium energy-medium protein (MEMP), Medium energy-high protein (MEHP), High energy-low protein (HELP), High energy-medium protein (HEMP) and high energy-high protein (HEHP). The starter diets (Table 1) were formulated using maize, maize bran, groundnut cake, fish meal, bone meal, limestone, lysine, methionine, salt and chick premix. Feed intake was recorded on daily basis, while body weights and body weight gains were recorded weekly. Feed conversion ratios were calculated on weekly basis.

Table 1: Ingredients composition of experimental starter chicks diets

	Metabolisable energy (kcal kg^{-1} diet)								
	2500			2700			2900		
Protein (%)									
Ingredients (%)	18 (LELP)	20 (LEMP)	22 (LEHP)	18 (MELP)	20 (MEMP)	22 (MEHP)	18 (HELP)	20 (HEMP)	22% CP (HEHP)
Maize	14.50	14.50	13.00	31.00	30.00	29.00	52.00	52.00	50.00
Maize offal	58.50	51.70	49.10	42.00	37.40	33.20	20.80	15.20	13.60
Groundnut cake	20.00	28.00	29.10	20.70	25.80	30.00	20.20	25.00	25.00
Fish meal	2.20	1.00	4.00	1.50	2.00	3.00	2.20	3.00	6.60
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Lysine	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Methionine	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Salt	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis (%)									
Energy (kcal kg^{-1} diet)	2551.35	2558.23	2556.56	2703.92	2703.52	2703.66	2901.88	2911.48	2905.76
Crude protein	18.32	20.39	22.40	18.02	19.80	22.00	18.01	20.07	22.04
Crude fibre	7.45	7.13	6.92	6.09	5.84	5.60	4.25	3.92	3.75
Ether extract	2.88	3.19	3.29	3.26	3.48	3.66	3.74	3.98	4.03
Lysine	1.15	1.24	1.38	1.18	1.28	1.40	1.16	1.37	1.52
Methionine	0.46	0.47	0.54	0.48	0.52	0.55	0.50	0.58	0.65
Energy: Protein ratio	139.27	125.46	114.13	150.05	136.93	122.89	161.34	145.07	131.84
Determined analysis (%)									
Moisture	6.30	5.70	5.00	5.70	5.30	5.70	6.30	6.30	6.00
Crude protein	18.42	20.62	22.61	18.89	20.39	22.37	18.39	20.89	22.90
Crude fibre	9.00	8.63	8.00	7.35	6.53	6.00	5.31	5.00	4.40
Ether extract	4.00	5.00	5.50	4.45	5.00	5.50	8.02	8.69	9.60
Ash	8.35	9.50	10.00	8.00	8.67	9.98	6.70	8.35	8.35

*Premix manufactured by Bio-Mix, supplying the following per 2.5 kg: Vitamin A: 12,000,000.00 IU, Vitamin D: 4,000,000.00 IU, Vitamin E: 40,000.00 mg, Vitamin K: 2,500.00 mg, Vitamin B1: 2,500.00 mg, Vitamin B2: 6,000.00 mg, Vitamin B6: 4,000.00 mg, Vitamin B12: 20.00 mg, Biotin: 120.00 mg, Niacin: 40,000.00 mg, Pantothenic acid: 10,000.00 mg, Folic acid: 1,200.00 mg, Choline chloride: 400,000.00 mg, Manganese: 100,000.00 mg, Zinc: 50,000.00 mg, Iron: 30,3000.00 mg, Copper: 10,000.00 mg, Iodine: 1,500.00 mg, Selenium: 250.00 mg, Cobalt: 250.00 mg, Antioxidant: 2,000.00 mg, LELP: Low energy-low protein, LEMP: Low energy-medium protein, LEHP: Low energy-high protein, MELP: Medium energy-low protein and MEMP: Medium energy-medium protein, MEHP: Medium Energy-high protein, HELP: High energy-low protein, HEMP: High energy-medium protein and HEHP: High energy-high protein

The chicks were fed the various treatment diets for a period of seven weeks (from 2-9 weeks of age). Feed and water were provided *ad libitum.* Birds were vaccinated against Gumboro (1st and 2nd vaccination), New castle disease, Fowl pox, Fowl cholera and Fowl typhoid as described by NVRI[12].

Chemical analysis: Proximate analysis for dry matter, moisture, crude protein, crude fibre, ether extract, ash and nitrogen free extract of the starter chicks' diets were carried out as described by the AOAC[13].

Statistical analysis: Data collected on feed intake, body weight, body weight gain, feed conversion ratio and water intake of the starter chicks were subjected to two-way analysis of variance (ANOVA) as described by Steel and Torrie[14] using the general linear model. Where significant difference was found among the treatment means, duncan multiple range test (DMRT) was used to separate the means[15].

RESULTS AND DISCUSSION

Feed Intake: The interaction and main effects of dietary energy and protein are shown on Table 2-4. Birds fed on 2500, 2700 and 2900 ME (kcal kg^{-1}) diets, showed increase in feed intake from 124.97-205.31 g, 127.70-143.80 g and 139.60-171.50 g (Table 2), respectively with increase in crude protein levels from 18, 20 and 22%, respectively. This result showed that feed intake increase with decrease in energy-protein ratio (Table 3), which is in agreement with a previous study conducted by Nahashon *et al.*[16] who reported that at hatch to 8 weeks of age, the Pearl Grey guinea fowl pullets fed diets containing 24% CP diet consumed more feed ($p>0.05$) than those fed 20 and 22% CP diets. The present study also in agreement with the findings of Leeson *et al.*[17] who reported that low-CP diets significantly depressed appetite in poultry (Table 4).

Birds fed diets containing 18% CP showed increase in feed intake (124.97 g, 127.70 g and 139.60 g) per energy level. At higher CP (22%) feed intake decreased (205.31 g, 143.80 g

Table 2: Interaction effects of dietary energy and protein on the performance of chicks

	Metabolisable energy (kcal kg^{-1} diet)									
	2500			2700			2900			
Protein (%)										
Parameters	18 (LELP)	20 (LEMP)	22 (LEHP)	18 (MELP)	20 (MEMP)	22 (MEHP)	18 (HELP)	20 (HEMP)	22 (HEHP)	SEM
Feed intake (g week^{-1} bird^{-1})	124.97^{e}	150.37^{c}	205.31^{a}	127.70^{de}	126.72^{de}	143.80^{cd}	139.60^{cde}	149.91^{c}	171.50^{b}	5.10***
Body weight (g bird^{-1})	387.00^{d}	499.17^{bc}	630.83^{a}	393.33^{d}	400.83^{d}	433.33^{cd}	470.33^{bc}	500.00^{b}	600.67^{a}	22.17***
Body weight gain (g bird^{-1})	281.17^{d}	386.67^{bc}	524.17^{a}	282.50^{d}	292.50^{d}	325.83^{cd}	362.00^{bc}	400.00^{bc}	492.33^{a}	21.90***
Feed conversion ratio	3.14^{ab}	2.74^{abc}	2.74^{abc}	3.22^{a}	3.03^{ab}	3.12^{ab}	2.72^{abc}	2.62^{bc}	2.43^{c}	0.16*
Water intake (mL bird^{-1} week^{-1})	409.93^{bc}	559.30^{a}	517.07^{ab}	459.70^{abc}	383.20^{c}	407.70^{bc}	448.67^{abc}	429.17^{bc}	472.03^{abc}	34.17*
Energy:Protein Ratio	138.89	125.00	113.64	150.00	135.00	122.73	161.11	145.00	131.82	

a-e Means in the same row with different superscripts are significantly different (*p<0.05, ***p<0.001), SEM: Standard error of mean, LELP: Low energy-low protein, LEMP: Low energy-medium protein, LEHP: Low energy-high protein, MELP: Medium energy-low protein and MEMP: Medium energy-medium protein, MEHP: Medium energy-high protein, HELP: High energy-low protein, HEMP: High energy-medium protein and HEHP: High energy-high protein

Table 3: Main effect of dietary energy on the performance of chicks

	Energy levels (kcal ME kg^{-1} diet)			
Parameters	2500	2700	2900	SEM
Feed intake (g bird^{-1} week^{-1})	160.22^{a}	132.74^{b}	153.67^{a}	5.10**
Body weight (g)	505.67^{a}	409.17^{b}	525.33^{a}	22.17**
Body weight gain (g)	397.11^{a}	300.28^{b}	418.11^{a}	21.90**
Feed conversion ratio	2.88^{a}	3.12^{a}	2.59^{b}	0.16**
Water Intake (mL bird^{-1} week^{-1})	494.10^{a}	416.87^{b}	449.96^{ab}	34.17*

a,b Means in the same row with different superscripts are significantly different (p<0.05), SEM: Standard error of mean and NS: Non significant

Table 4: Main effect of dietary protein on the performance of chicks

	Protein levels			
Parameters	18% CP	20% CP	22% CP	SEM
Feed intake (g bird^{-1} week^{-1})	130.76^{c}	142.33^{b}	173.54^{a}	5.10**
Body weight (g)	416.89^{c}	468.33^{b}	554.94^{a}	22.17**
Body weight gain (g)	308.56^{c}	359.72^{b}	447.44^{a}	21.90**
Feed conversion ratio	3.03	2.80	2.76	0.16^{NS}
Water Intake (mL bird^{-1} week^{-1})	438.10	457.22	465.60	34.17^{NS}

a,b Means in the same row with different superscripts are significantly different (p<0.05), SEM: Standard error of mean and NS: Not significant

and 171.50 g) per energy level (2500, 2700 and 2900 kcal kg diets), respectively. This result agrees with the findings of Nahashon *et al.*[16] and Golian and Maurice[18], who reported that birds on lower caloric diets will tend to consume more feed to meet their energy needs than those birds fed diet containing higher calories.

Body weight: The body weight of starter chicks that consumed 2500 ME (kcal kg^{-1}) at 22% CP was significantly higher (630.83 g). Their body weight was the lowest (387.00 g) when fed 2500 ME (kcal kg^{-1}) diets at 18% CP due to their high feed intake (205.31 g). The result of the current study showed that maximum body weight was obtained with E:P-ratio of 114:13 (at 22% CP) while Niu *et al.*[19] and Okoye[20] reported maximum growth rate at E:P-ratios of 126:1 to 163:1 and 123:1 respectively. Similarly, in pullet chicks, dietary protein increased body weight to from 416.89-554.94 g bird^{-1} week^{-1} at 18 and 22% CP, respectively (Table 4). Yusuf *et al.*[21] reported maximum body weight of starter chicks at 22% CP.

Body weight gain: Starter chicks fed 2500 and 2900 ME (kcal kg^{-1}) diets at 22% CP showed significantly higher body weights gain (524.17 and 492.33 g, respectively) compared to those fed on 18 and 20% CP diets which showed a significantly lower body weight gains (281.17 and 362.00 g, respectively). This result is in agreement with the findings of Yusuf *et al.*[21] who reported a significant difference (p<0.05) in body weight gain of broiler chicks. Similarly, body weight gain increased with increased energy intake at low CP intake (18% CP). This result agrees with the findings of Sizemore and Siegel[22] who reported a significantly linear increase in weight gain as caloric intake increased.

Feed conversion ratio: The feed conversion ratio of starter chicks was significantly reduced when crude protein levels were increased from 18-22% (Table 2). Starter chicks fed on 2500 and 2900 ME (kcal kg^{-1}) diets at 22% CP showed better feed conversion ratios (2.74 and 2.43, respectively) compared to those fed diet containing 18% CP (3.14 and 2.72,

Table 5: Effects of dietary energy and protein on cost analysis of chicks

	Metabolisable energy (kcal kg^{-1} diet)									
	2500			2700			2900			
Protein (%)										
Parameters	18 (LELP)	20 (LEMP)	22 (LEHP)	18 (MELP)	20 (MEMP)	22 (MEHP)	18 (HELP)	20 (HEMP)	22 (HEHP)	SEM
Total feed intake (g)	874.79^{d}	1052.59^{b}	1437.17^{a}	893.93^{cd}	887.03^{cd}	1006.58^{b}	977.24^{bc}	1049.34^{b}	1200.50^{b}	29.80***
Feed cost (₦ kg^{-1})	65.62	68.11	70.85	71.07	74.64	75.93	78.83	81.73	84.34	-------
Feed cost (₦/25 kg bag)	1640.50	1702.75	1771.25	1776.75	1866.00	1898.25	1970.75	2043.25	2108.50	-------
Cost of total feed intake (₦)	57.40^{g}	71.69^{de}	101.82^{a}	63.53^{fg}	66.21^{ef}	76.43^{cd}	77.04^{cd}	85.76^{c}	101.25^{b}	2.15***
Total weight gain (g)	281.17^{d}	386.67^{bc}	524.17^{a}	282.50^{d}	292.50^{d}	325.83^{cd}	362.00^{bc}	400.00^{b}	492.33^{a}	21.90***
Feed cost kg^{-1} gain (₦ kg^{-1} gain)	204.15^{abcd}	185.40^{cd}	194.25^{bcd}	224.88^{ab}	226.36^{abc}	234.57^{a}	212.82^{abcd}	214.40^{abcd}	205.65^{d}	12.10*

$^{a-g}$Means in the same row with different superscripts are significantly different (*p<0.05, ***p<0.001), SEM: Standard error of mean and LELP: Low energy-low protein, LEMP: Low energy-medium protein, LEHP: Low energy-high protein, MELP: Medium energy-low protein and MEMP: Medium energy-medium protein, MEHP: Medium Energy-high protein, HELP: High energy-low protein, HEMP: High energy-medium protein and HEHP: High energy-high protein

respectively). This implied that birds fed diet containing 18% CP required more feed to put on 1g of body weight gain compared to those fed diet containing 22% CP which required less feed. This is in agreement with the findings of Niu *et al.*[19], Yusuf *et al.*[21] and Jensen *et al.*[23], who reported a significantly lower FCR with high-energy starter diets. In a similar study with turkey poults, it was reported that feed efficiency of turkeys improved as the level of fat increased[24,25].

Water intake: Water intake of pullet chicks (449.10, 416.87 and 449.96 mL bird^{-1} week^{-1}) significantly (p<0.05) decreased with increased energy at 2500, 2700 and 2900 (kcal kg^{-1}) diets respectively (Table 3). Agri-Facts[26] reported that water intake of livestock and poultry may depend on physiological and environmental conditions such as type and size of animal or bird, activity level, type of diet, temperature and water quality. Increasing crude protein from 18, 20 and 22% has no significant effect on water intake of pullet chicks.

Cost analysis: Cost of producing 1 kg of feed was affected by both energy and protein levels (Table 5). At each energy level [2500, 2700 and 2900 ME (kcal kg^{-1})] cost of producing 1 kg of feed increased linearly (from ₦65.62 to ₦84.34) as the protein level of the diet increased from 18-22%. Similarly, by keeping the protein level constant (either at 18, 20 and 22% CP) cost of producing 1 kg of diet also increased linearly (from ₦57.40 in LELP to ₦101.25 in HEHP) as the energy level increased from 2500-2900 ME (kcal kg^{-1}) diet. This showed that the higher the protein and energy levels, the higher the cost of feed. Similar result was reported by Yusuf *et al.*[21] who noted that cost of feed intake increased with increase in CP of the diet at the 3 energy levels. This was not so with increase in energy level at 20 and 22% CP which agrees with the findings of Sizemore and Siegel[22] who reported that birds eat to satisfy their energy requirement. Feeding birds on medium energy diet (2700 ME (kcal kg^{-1}) showed that feed cost kg^{-1} gain (₦ kg^{-1} gain) increased with increase in protein level.

CONCLUSION

The study showed that, starter chicks fed low energy and high protein diet [2500 ME (kcal kg^{-1}) and 22% CP], grew significantly faster and had lower feed cost kg^{-1} weight gain (₦194.25). Based on the findings in this experiment, it is recommended that, starter chicks should be fed on 2500 ME (kcal kg^{-1}) diet at 22% crude protein.

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