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Growth performance of broiler starter chickens fed varying levels of fibre and energy in multi-fibre source-based diets.

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Target Audience: Nutritionists, Poultry Producers, Researchers, Feed millers

Abstract

There is dearth of information on the crude fibre (CF) tolerance limit of broiler chickens for optimum performance in relation to dietary metabolisable energy (ME) level in the tropics. Hence, this study examined the CF-dietary energy relationship in multi-fibre source-based broiler starter diets at fixed calorie: protein ratio of 123:1. Two hundred and sixteen day-old unsexed Obamarshal broiler chicks were allotted to nine treatments at 24 birds each with three replicates per dietary treatment and fed for 28 days with diets containing ME levels of 2600, 2800 and 3000 ME (kcal/kg) and CF levels of 4, 8 and 12% per energy level to determine their optimal inclusion levels. Live weight, average daily gain (ADG), feed intake, feed conversion ratio (FCR), protein intake, protein efficiency ratio (PER), calorie intake, fibre intake, water intake, water intake: feed intake, water intake: weight gain, faecal output and mortality rate were evaluated and analysed statistically using 3x3 factorial arrangement and significant means separated by Duncan's Multiple Range Test at P<0.05.Results of this study indicated that ADG (28.25 and 28.69g), FCR (1.95 and 2.06) and PER (2.26 and 1.97) were optimized (P<0.05) and similar (P>0.05) in broiler starters fed diets containing 8% CF at 2800 and 3000 ME (kcal/kg) respectively. However, these parameters were lower (P<0.05) in broiler starters fed diets containing 2600 ME (kcal/kg) at the three CF levels. Feed cost per kg weight gain was least in broiler starters fed 8%CF diet at 2800KcalME/kg and relatively better than at 8%CF-3000Kcal ME /kg diet. Conclusively, optimum growth and minimal feed cost were obtained with broiler starters raised on diet containing 8% CF at 2800ME(kcal/kg).

Keywords: Broiler starter, crude fibre, metabolisable energy, growth.

Description of Problem

Unlike in the ruminants, crude fibre (CF) has dual status in monogastric animal nutrition. It is a nutrient as well as an anti-nutrient (1, 2) against the old consensus that CF is gut filler (3). As a nutrient, CF has feeding value being a reservoir of hidden nutrients (4,5) and as an anti-nutrient; it impairs the processes of digestion and absorption via several mechanisms (6). Despite the digestive limitations of the monogastrics to digest CF appreciably, it is an essential component of the monogastric animal diet (7, 8). Cereals and legumes and their by-products always constitute the bulk of commercial poultry diets and they contain significant amount of CF. Therefore, dietary fibre deficiency is rare but its excessive inclusion cannot be ruled out, especially with plant protein - based diets. In addition to the fibre from feed, poultry housed in floor systems are able to ingest fibre-rich materials from the floor (7,8).

It is common knowledge that dietary energy content governs primarily the voluntary feed intake of the monogastric animals. Hence, their nutrient requirements are always determined in relation to it (9). However, the CF tolerance limit value of the broiler chickens for optimum performance in relation to dietary energy level has not been demonstrated empirically. Owing to the caloric value of CF via caecal microbial fermentation as in pseudo-ruminants and herbivorous wild avian species (2, 6), It is reasonable to assume that CF requirement of broiler chickens may be higher at lower dietary energy but meeting the other nutrients requirement for optimum performance may be limiting. This experiment, therefore, examined the growth response of broiler chickens to varying levels of CF in relation to dietary energy levels during the starter phase in a tropical environment.

Materials and Methods

Experimental site

The study was conducted at the Poultry Unit, of 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% (10).

Experimental diets

Nine treatment diets coded A, B, C, D, E, F, G, H and I in ascending order of dietary metabolisable energy (ME) levels was formulated. The caloric density of the diets was at three levels, namely: 2600, 2800 and 3000 (ME kcal/kg) and three dietary CF levels (4, 8 and 12%) per energy level to give a 3 X 3 factorial design. The compositions of the starter diets are shown in Table1. 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 (11,5), while rice offal was used to vary the fibre level at the expense of maize. Inclusion of blood meal did not exceed the tolerance level of 9% (12). Palm oil was added to all diets at varying levels for its extra caloric effects and in particular 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 (13). Sterilized sand was used at maximum of 5% in diet A (14) 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. The crude protein (CP) ranged from 21 to 24% with average calorie: protein ratio of 123:1. The calorie: protein ratio was moderately 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 experimental birds (15).

Experimental birds and management

A total of 216 day-old unsexed Obamarshal strain of broiler chicks were allotted to the nine treatment diets at 24 birds per diet. Eight birds were allotted to each replicate and there were 3 replicates per treatment arranged in a Completely Randomized Design. The birds were housed in the deep litter units or cells measuring 45 x 75 cm (breadth and length respectively). Fine water erosion sand was used as the litter material and at a depth of 4 to 5cm. Sand was used instead of wood shavings (of plant origin) as litter material to prevent the birds from picking fibre from litter (8). Routine medications and vaccinations were also followed as and when due (16).

Data Collection

Performance characteristics:

Initial body weight of birds in the replicate groups was taken at day old. Body weight and feed intake of the replicate groups of birds were also measured weekly and expressed on daily basis. Average daily weight gain (ADG) was obtained by subtracting initial body weight from final body weight of the birds and divided by 28 days. Feed conversion ratio (FCR) was computed by dividing daily feed intake by daily weight gain while protein efficiency ratio (PER) was calculated by dividing protein intake by weight gain. Protein, fibre and calorie intakes were also calculated as the products of the feed intake and dietary contents of protein, fibre and calorie respectively. Volume of water served and leftover in 24 hours for each replicate was measured using a measuring cylinder to determine water intake. Water intake was corrected for evaporative losses by leaving an open drinker with known volume of water inside the poultry house and leftover volume of water was also measured (17). Water intake: feed intake ratio and water intake: weight gain ratio were calculated as described by (17). Mortality was recorded, as it occurred to compute percent mortality rate on dietary treatment basis. The cost per kilogram of each diet was determined using the prevailing market prices of the feed ingredients as at the time experiment was conducted. The feed cost per unit weight gain of birds per diet was also calculated as a product of feed conversion ratio and diet cost per kg.

Faecal output:

Faecal collection from 2 sampled birds (closest to the replicate mean body weight) was for 3 days (26 to 28 days of age) after cage adjustment period of 3 days. Faecal collections were carried out every 24 hours and were oven dried at 70°C to arrest microbial activities until constant weight was obtained as faecal output.

Chemical analysis:

Samples of experimental diets were subjected to analysis for proximate fractions namely dry matter, crude protein, crude fibre, crude fat and ash, while the nitrogen-free extract was determined by difference (18).

Statistical analysis:

Data collected were subjected to one way analysis of variance (ANOVA) using a 3x3 factorial arrangement made up of 3 levels of ME (2600, 2800 and 3000 ME kcal/kg) and 3 levels of crude fibre (4, 8 and 12%) per energy level using SAS (19) statistical package. Significant means were also separated using Duncan's Multiple Range Test (20) of the same package at 5% probability level.

Results and Discussion

The proximate contents of the diets (Table 1) showed the variations within the diets as dry matter (89 to 90%), crude protein (20 to 24%) and ash (11 to 13%). Nitrogen Free-Extract (NFE) decreased progressively as the crude fat content of the diets increased in ascending order of dietary energy levels. Within each energy level, crude fat increased as dietary crude fibre level increased. Irrespective of the variations in some determined chemical components such as crude protein, the diets maintained similar calorie: protein ratio to minimize the effect of varying calorie: protein ratio on voluntary feed intake of the birds (Table 1). Generally, the proximate values especially protein fell within the range of recommended crude protein values (22-23%) for broiler starters (21) while the calorie: protein ratios were also close to the recommendations of 122:1 for broiler starters (22).

The performance characteristics of broiler starters fed varying crude fibre and energy levels are shown in Tables 2 and 3 respectively. Weight gain was significantly increased (P<0.05) at 8% CF level while it was decreased (P<0.05) at 12% CF. Irrespective of CF level, the birds fed 2800 and 3000 ME (kcal/kg) diets had similar (P>0.05) and better (P<0.05) daily weight gain than those on 2600 ME (kcal/kg) diet (Table 3). The optimum growth performance attained on the diets containing 8%CF at

Table 1: Percentage Composition of Experimental diets for Broiler Starters

	2,600Kcal.ME/Kg			2,800Kcal.ME/Kg			3,000Kcal.ME/Kg		
Feed ingredients	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Maize(2%CF)	40	33	14	48	32	22	40	24	14
Wheat Offal(8.5CF)	18	18	18	10	10	5	10	10	5
Rice Offal(38%CF)	2	12	23	2	11	24	2	11	24
Palm Kernel Cake(17.5%CF)	2	2	2	5	10	5	5	10	5
Groundnut (5%CF)	17	17	20	15	15	19	15	15	19
Blood meal(1%CF)	6	6	6	8	8	8	10	10	10
Danish Fish Meal (1%CF)	3	3	3	4	4	4	5	5	5
Palm Oil	2	3	8	3	5	8	6	10	13
Sterilised sand	5	1	1	2	-	-	2	-	-
[a]Fixed Ingredients	5	5	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100	100	100
Cost of feed (₦/Kg)	73.4	67.9	66.8	79.1	74.1	70.0	86.2	79.3	72.1
M.E (kcal/kg)	2622.3	2628.3	2609.0	2798.7	2820.3	2785.9	3007.6	3029.1	2994.8
[b]Determined Fractions (%):									
Dry matter	90.1	90.0	89.7	90.3	89.7	89.9	89.9	89.3	89.1
Crude protein	20.5	20.6	21.0	22.7	22.4	22.8	23.7	24.6	23.8
Crude fat	5.35	7.14	10.27	6.30	10.23	12.18	8.47	12.5	16.0
Nitrogen – free extract	49.3	46.6	38.9	47.2	41.7	34.2	43.8	35.7	28.6
Crude fibre	4.09	7.85	11.75	4.20	7.80	11.85	3.97	7.65	12.0
Ash	12.1	12.2	13.2	11.8	12.4	12.5	13.2	13.0	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; ME- calculated Metabolizable Energy

Table 2: Performance characteristics of broiler starters fed varying levels of crude fibre

Performance parameters	Dietary crude fibre level (%) 4	8	12	± SEM
Initial body weight (g/b)	40.3	40.3	40.5	1.21
Body weight at 28 days (g/b)	746.7^{b}	804.5^{a}	734.7^{c}	3.17
Weight gain (g/b/d)	25.2^{b}	27.3^{a}	24.5^{c}	0.15
Feed intake (g/b/d)	52.2^{c}	57.9^{b}	60.3^{a}	0.85
Feed conversion ratio	2.08^{b}	2.13^{b}	2.47^{a}	0.04
Protein efficiency ratio	2.11^{a}	2.02^{b}	1.79^{c}	0.03
Protein intake (g/b/d)	11.9^{c}	13.2^{b}	13.8^{a}	0.18
Calorie intake(Kcal/b/d)	146.7^{c}	162.6^{b}	170.6^{a}	2.30
Crude fibre intake (g/b/d)	2.24^{c}	4.71^{b}	7.37^{a}	0.52
Water intake (ml/b/d)	123.8^{c}	134.1^{b}	143.9^{a}	1.85
Water intake: feed intake ratio (ml/g/d)	2.45	2.31	2.39	0.52
Water intake: weight gain ratio (ml/g/d)	4.93^{b}	5.03^{b}	5.90^{a}	0.07
Faecal output (g/b/d) at 26-28days	35.2^{c}	40.7^{b}	49.4^{a}	1.84
Mortality rate (%)	2.22	1.11	3.33	0.76

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

Table 3: Effect of varying energy levels on performance of broiler starters

Performance parameters	Dietary energy level (Kcal.ME/Kg) diet 2600	2800	3000	± SEM
Initial body weight (g/b)	40.25	40.25	40.33	
Body weight at 28 days (g/b)	724.4^{b}	776.4^{a}	776.9^{a}	3.17
Weight gain (g/b/d)	24.3^{b}	26.3^{a}	26.3^{a}	0.15
Feed intake (g/b/d)	59.3^{a}	54.8^{b}	56.4^{b}	0.85
Feed conversion ratio	2.44^{a}	2.09^{b}	2.15^{b}	0.04
Protein efficiency ratio	1.94^{c}	2.05^{a}	1.93^{b}	0.03
Protein intake (g/b/d)	12.6^{b}	12.6^{b}	13.8^{a}	0.18
Calorie intake(Kcal/b/d)	155.3^{b}	154.6^{b}	170.0^{a}	2.30
Crude fibre intake (g/b/d)	4.97^{a}	4.62^{c}	4.73^{b}	0.52
Water intake (ml/b/d)	129.9^{b}	124.7^{b}	147.2^{a}	1.85
Water: feed intake ratio	2.19^{c}	2.34^{b}	2.62^{a}	0.01
Water intake: weight gain ratio	5.35^{a}	4.99^{b}	5.51^{a}	0.07
Faecal output (g/b) at 26-28days	40.9	41.9	42.5	1.84
Mortality rate (%)	1.11	2.22	3.33	0.76

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

2800 to 3000 ME confirmed that moderate levels of dietary fibre and adequate dietary energy are crucial to optimum growth performance of broilers (5, 7). Previous authors (22, 23) recommended maximum 5%CF for broilers; however, our results are in accordance with the recommendations of 8-10% CF for broilers (8). The depressed growth rate at 2600 ME (kcal/kg) diet irrespective of fibre levels is an indication that this energy level was inadequate despite the similar calorie: protein ratios in the test diets and despite earlier recommendations (22, 24). The age of broiler chicken in this study revealed their CF tolerance limit or requirement value, and confirmed the dual status of CF in broiler chicken nutrition as a growth stimulant and depressant based on its inclusion level in the diet. The effects of both statuses occur via several mechanisms such as increased or reduced consumption of feed and enhancement or impairment of digestion and absorption of nutrients (25).

Consumption of feed, protein, calorie, fibre and water increased (P<0.05) linearly with the incremental levels of crude fibre ranging from 4 to 12%. Although, the effect was not linear like that of varying CF levels, consumption of feed, protein, calorie, fibre and water were also significantly affected by varying dietary energy levels. Feed and CF intakes were highest (P<0.05) at 2600 ME (kcal/kg) while calorie,

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

Performance parameters	2600			2800			3000Kcal.ME/l g diet			
	A	B	C	D	E	F	G	H	I	
	4	8	12CF	4	8	12%CF	4	8	12%CF	± SEM
Initial body weight (g/b)	40.0	40.3	40.5	40.5	40.2	40.0	40.3	40.4	40.5	1.72
Body weight at 28 days (g/b)	715.6^{de}	739.6^{cd}	718.0^{de}	749.8^{bc}	830.8^{a}	772.9^{b}	774.8^{b}	843.0^{a}	713.2^{e}	8.90
Weight gain (g/b/d)	24.1^{cd}	24.9^{bc}	23.8^{d}	25.1^{bc}	28.3^{a}	25.6^{b}	26.3^{b}	28.7^{a}	24.0^{cd}	0.39
Feed intake (g/b/d)	55.1^{c}	59.4^{b}	63.4^{a}	50.9^{d}	55.1^{c}	58.4^{bc}	50.7^{d}	59.2^{b}	59.3^{b}	1.14
Feed conversion ratio	2.29^{bc}	2.38^{b}	2.66^{a}	2.03^{d}	1.95^{e}	2.28^{bc}	1.93^{e}	2.06^{cd}	2.47^{ab}	0.06
Protein efficiency ratio	2.05^{bc}	1.99^{cd}	1.77^{e}	2.15^{ab}	2.26^{a}	1.90^{d}	2.12^{bc}	1.97^{cd}	1.70^{e}	0.04
Protein intake (g/b/d)	11.8^{de}	12.6^{c}	13.5^{b}	11.8^{e}	12.5^{cd}	13.5^{b}	12.4^{cde}	14.6^{a}	14.5^{a}	0.27
Calorie intake (kcal/b/d)	144.4^{d}	154.7^{c}	166.7^{b}	143.4^{d}	154.3^{c}	166.2^{b}	152.3^{cd}	178.8^{a}	179.1^{a}	3.35
Crude fibre intake (g/b/d)	2.37^{c}	4.89^{b}	7.66^{a}	2.22^{c}	4.52^{b}	7.11^{a}	2.11^{c}	4.74^{b}	7.33^{a}	0.12
Daily water intake (ml/b)	120.3^{de}	133.4^{c}	136.2^{c}	112.3^{e}	121.4^{d}	140.4^{bc}	138.9^{bc}	147.3^{a}	155.4^{a}	2.91
Water: feed intake ratio (ml/g/d)	2.18^{c}	2.25^{bc}	2.15^{c}	2.41^{abc}	2.20^{c}	2.41^{abc}	2.75^{a}	2.49^{abc}	2.62^{ab}	0.12
Water intake: weight gain ratio (ml/g/d)	4.98^{bc}	5.34^{bc}	5.73^{ab}	4.88^{c}	4.62^{d}	5.49^{bc}	4.94^{c}	5.13^{bc}	6.47^{a}	0.23
Faecal output (g/b/d)	35.1^{b}	37.9^{b}	49.5^{a}	35.0^{b}	41.5^{ab}	49.1^{a}	35.3^{b}	42.5^{ab}	49.6^{a}	2.80
Mortality rate (%)	0.00	0.00	4.17	4.17	0.00	4.17	4.17	4.17	4.17	3.40
[1]Cost of feed (₦/Kg)	73.4	67.9	66.8	79.1	74.1	70.0	86.2	79.3	72.1	-
Feed cost/kg weight gain (₦)	168.1^{ab}	161.7^{b}	177.7^{a}	160.5^{b}	144.6^{c}	159.7^{b}	166.4^{ab}	163.3^{b}	177.9^{a}	4.17

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

[1]Computed from Table 1

protein and water consumption was higher ($P<0.05$) at 3000 ME (kcal/kg) diet than at other energy levels. The dilution effect of dietary CF (4, 26) was responsible for the observed increment in the consumption of feed within the gut capacity of the birds up to the optimum fibre levels, as reflected in the optimum weight gain. This pattern of feed intake assisted the birds to satisfy the requirements for nutrients and energy as reflected in the similarity in the intake of nutrients and calorie. These results agreed with those of (7, 26, 27). Similarly, the calorie, protein and water consumption of the birds increased as the dietary ME level increased, thereby maximizing weight gain at 2800 and 3000 ME kcal/kg. This was provoked by the tendency of the birds to over consume high-energy diets (15).

The feed conversion ratio (FCR) of birds fed 4 and 8% CF levels were similar ($P>0.05$) and better than those placed on 12% CF. However, the protein efficiency ratio (PER) deteriorated ($P<0.05$) as CF level increased from 4 to 12%. The PER was maximized ($P<0.05$) at 2800 ME (kcal/kg), followed by 3000 ME (kcal/kg) diet and least for 2600 ME (kcal/kg). FCR was similar ($P>0.05$) and superior ($P<0.05$) for the birds on 2800 and 3000 ME (kcal/kg) diets than those fed 2600 ME kcal/kg diet. The water: feed intake ratio was uniform ($P>0.05$) across the fibre levels. However, the water intake: weight gain ratio was also similar ($P>0.05$) and narrower ($P<0.05$) at 4 and 8% CF levels than at 12% CF which had wider ($P<0.05$) ratio because of poor growth rate. With incremental levels of dietary energy, water: feed intake ratio became wider arising from increased water intake. However, the water intake: weight gain ratio was narrower ($P<0.05$) at the medium energy level than at other energy levels, which was similar ($P>0.05$). The increased water intake as dietary CF increased might be due to the hydration properties of soluble and insoluble fibres such as water-holding capacity, water-swelling capacity, solubility and viscosity in the gut (6, 28). Although the rectal temperature of the birds was not measured, it is highly probable that heat load on the birds was increased as the energy content of their diets increased due to overconsumption of calorie. Water has high latent heat of vaporization, with 540 calories of heat absorbed per gram of water hence; more water was consumed as dietary ME increased so as to dissipate excess heat by vaporization as in panting and defecation. A similar pattern of water consumption was previously reported (5, 29). Water deprivation could jeopardize growth performance on the strength of the relationship or ratio of water intake to feed intake, which is of the order of 2-3:1 (30). The water intake: feed intake ratio was also similar across treatment diets (2.5:1) irrespective of the fibre level, while the ratio became wider (2-3:1) as dietary energy level increased. This suggests that more water was required by the birds to dissipate heat from the body.

The faecal output (on air-dried basis) was influenced by the CF levels, with the largest amount of faeces voided by the birds fed 12% CF, whereas faecal output was unaffected ($P>0.05$) by the range of dietary energy levels. This showed the faecal-bulking effect of 12% fibre at all the energy levels (4, 5). The slower passage rate of digesta in the gut coupled with poor bacterial action on insoluble fibres and bacterial fermentation of soluble fibres in the paired caeca are accountable for impaired digestion and absorption. The resultant effect of impaired digestion and absorption is the loss of nutrients via faeces as crude fibre level increased (31, 32).

The interaction effect of the varying CF and energy levels on performance of broiler starters is shown in Table 4. The birds fed diets E and H (containing 8% CF at 2800 and 3000 ME) had the best values of growth rate, FCR and PER, whereas these parameters for birds on 12% CF at 2600 ME kcal/kg (diet C) were the poorest. Within each energy level, consumption of feed, fibre, protein, calorie and water increased as dietary CF increased, though in some cases, the increment was not significant. The water: feed intake ratios of the treatment groups tended to be uniform ($P>0.05$) across the CF levels within the dietary energy levels, with the generally wider ($P<0.05$) ratios for the treatment groups on the highest energy level. Likewise, the water intake: weight gain ratios were narrower ($P<0.05$) and similar ($P>0.05$) for the treatment groups except those on the 12% CF diet at the three energy levels, which had wider ($P<0.05$) ratio. The water intake: weight gain ratios ranged from 4.6:1 to 6.5:1 for diets E and I respectively. Faecal output also increased ($P<0.05$) as dietary CF increased within the energy levels, with the largest quantity of faeces voided by the chicks on the 12% CF diets. Factors (animal, nutritional and environmental), which affect weight gain and feed intake (11, 22) also affect the values of FCR and PER. For example, PER was improved at 4%CF while it was reduced at energy level of 2600. The reduction in the PER and FCR values as fibre level increased agreed with (11, 16). Possibly, stage of gut development did not allow full fibre utilization, thereby interfering with dietary protein utilization.

Mortality rate recorded for the treatment groups was not affected ($P>0.05$) by the variable factors individually or in combination (Tables 2, 3 and 4). Percentage mortality that was less than 5% suggesting the safety of the fibre and energy levels used which did not affect their health and metabolic statuses.

Conclusion and Applications

1. Dietary ME level, ranging from 2800 to 3000 ME (Kcal/kg) diet was shown to be adequate for broiler starters raised in the tropics while 2600 ME (Kcal/Kg) diet was inadequate.
2. Broilers starters fed metabolisable energy levels of 2800 and 3000 could tolerate the dietary CF level of 8%.
3. Optimum growth performance attained at 8% CF level beyond 5%CF commonly recommended underscores that CF is essential in broiler chicken nutrition while growth depressant effects of CF was manifested at 12%.
4. Higher dietary CF level decreased feed cost per kg live weight gain, while higher dietary energy level increased feed cost per kg live weight gain.
5. Conclusively, the 8% CF and 2800 ME (Kcal/Kg) diet appeared optimum for growth performance

and economy of production of starter broiler chickens.

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