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Effect of varying dietary fibre and energy levels in multi-fibre source-based diets on growth performance of broiler finisher chickens

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

Abstract

There is a need for constant review of empirical data relating crude fibre (CF) tolerance limit of broiler finishers to dietary energy level for optimum performance. On this note, this study was carried out to investigate the effect of varying levels of CF at 4, 8 and 12% and Metabolisable Energy (ME) levels of 2600, 2800 and 3000 ME (Kcal/Kg) in multi-fibre source-based diets maintained around calorie: protein ratio of 140:1 on the performance characteristics of broiler finishers during 5 – 8 weeks of age. Growth response parameters were evaluated and subjected to 3x3 factorial analysis in a complete randomised design and treatment means were separated at 5% probability level. The values of average daily weight gain (ADWG) (46.02 versus 47.49g) and feed conversion ratio (FCR) (3.41 versus 3.18) were maximised ($P<0.05$) and similar ($P>0.05$) for the birds on 12% CF diets at 2800 and 3000ME (kcal/kg) respectively. However, these two parameters were poorer ($P<0.05$) in birds fed diets containing 2600ME (kcal/kg) at the three CF levels. The values of protein efficiency ratio (PER) ranging from 1.37-1.61 were generally similar ($P>0.05$) across the diets. The superior values of ADWG and FCR at the optimal CF and ME levels indicated that both of them are essential in broiler finisher feeds. However, the feed cost per kg live weight gain were similar ($P>0.05$) between broilers fed medium and high energy feeds, though, numerically the feed cost was lower at 3000 than at 2800 ME (Kcal/Kg). The findings showed that 12% CF diet at 3000ME (kcal/kg) of feed gave optimum performance in broiler finishers at lower feed cost, thus indicating that broiler finishers can tolerate more than 5% recommended crude fibre

Keywords: Broiler finisher, crude fibre, metabolisable energy, calorie: protein ratio, performance

Description of Problem

The optimum biological performance of farm animals, especially the monogastrics is partly determined by feed quality. Feed quality is measured in terms of adequate amounts and correct proportions of the essential nutrients such as protein, minerals and vitamins to one another in animal feed in relation to its optimum energy content. Unlike cockerel, broiler chicken has genetic potential to attain live and dressed weights of 2.0kg and 1.5kg respectively in 6 to 8 weeks of age (1) provided feeding is adequate not only in quantity but also in quality. However, unless precaution is taken, feed quality may be compromised in several instances. Feed quality may be undermined by deficiency or excess of any of the essential nutrients as well as the metabolisable energy (ME) content of the feed in a bid to reduce feed cost by the farmer or to maximise profit by the commercial feed miller (2). The nutritional significance of crude fibre (CF) at moderate level in poultry nutrition was underscored by (3) which, agreed with (4) that CF is a 'forgotten' essential nutrient. Deficiency of CF unlike other essential nutrients is rare in monogastric animal feeds since most feeds are based on feedstuffs of plant origin. However, excess of CF cannot be ruled out, which may exceed the tolerance limit of the class of the animal. Excess of CF may occur through substitution of cereal grain proportion of animal feeds with fibrous agro-industrial by-products and also through feed formulation abuses on the part of commercial feed millers (2). The consensus is that monogastric animals unlike ruminants cannot tolerate appreciable amount of dietary CF because the CF components resist the action of endogenous digestive enzymes. For this reason, dietary CF levels of 3 to 5% have been commonly recommended for broilers (5) without recourse to dietary energy level, which primarily governs voluntary feed consumption. It was reported (6) that broiler starters could tolerate up to 8% dietary CF at 2800 and 3000 ME (Kcal/Kg) without the inclusion of enzyme for optimum growth performance.

Given the advantage of feed cost reduction at the instance of CF at 8% inclusion level for broiler starters with less developed gut (6), this study, therefore, examined the growth performance indices of finishing broiler chickens fed varying levels of CF and ME in multi-fibre source-based diets maintained within close calorie: protein ratio without enzyme addition.

Materials and methods

Experimental birds, diets and management

The experiment was carried out at the Poultry Unit of the Teaching and Research farm of the Emmanuel Alayande College of Education, Oyo, Nigeria. The broiler chickens, diets and management followed the same principles employed by (6) for the starter phase. Essentially, at 5 weeks of age, birds on the respective treatments in the starter phase were transferred into two-tier battery cage with 2 birds per cage compartment measuring 30x38x43cm^3 for length, breadth and height respectively. There were nine treatments and three replicates per treatment arranged in a completely randomized design. The birds were housed in such a way to allow separate feeding per replicate. Nine (9) broiler finisher diets as in Table 1 were formulated and fed from 5 - 8 weeks of age. The Obamarshal broiler chickens used for this study were those placed on the respective broiler starter diets of the study reported by (6). Feed and drinking water were supplied ad libitum and records of weekly feed and water consumption were kept per replicate. A plastic cup fixed securely onto the cage was used to serve known volume of water per two sampled birds on the basis of replicate. The sampled birds were denied access to water trough used to serve water to other birds. Water intake of the sampled birds was determined as described by (7). All standard management practices notably routine vaccination and medications applicable to the finisher phase were adopted as at when due (8).

Data Collection

Performance characteristics namely body weight gain, feed intake, feed conversion ratio, protein efficiency ratio and faecal output for the finisher phase were measured and/or computed using already established procedures (6).

Chemical analysis

Samples of experimental diets were subjected to analysis for proximate fractions namely dry matter, crude protein, crude fibre, crude fat, ash while the nitrogen-free extract was determined by difference according to the procedure of AOAC (1).

Statistical analysis

Data collected were subjected to one way analysis of variance in accordance with 3X3 factorial arrangement made up of made up of 3 levels of ME (2600, 2800 and 3000Kcal/ME/kg) and 3 levels of crude fibre (4, 8 and 12%) per energy level using (10) statistical package. Means were also separated using (11) of the same package at 5% probability level.

Results

The dry matter content of the diets ranged from 88 to 90%, while the CP ranged from 18 to 20% (Table 1). The ash content varied from 12 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. The diets maintained close calorie: protein ratio to minimize the effect of varying calorie: crude protein ratio on voluntary feed intake of the birds (Table 1).

Performance response (Table 2) showed that 8 and 12% CF levels maximized ($P<0.05$) weight gain as reflected in the mean body weight at 56 days irrespective of the starting body weight at 28 days of age. The values of FCR and PER were superior ($P<0.05$) at 8% CF level while these parameters were inferior ($P<0.05$) but similar ($P>0.05$) at 4 and 12% CF levels. However, consumption of feed, protein, calorie, fibre and water increased ($P<0.05$) linearly as dietary fibre increased. Faecal output also followed the same trend as feed intake in response to incremental CF levels. While mortality rate and water intake: weight gain were unaffected ($P>0.05$) by varying CF levels, the water: feed intake were similar ($P>0.05$) at 4 and 8% CF levels and wider ($P<0.05$) than the ratio recorded for the 12% CF level.

The main effect of varying dietary ME levels revealed similar (P>0.05) and better (P<0.05) growth rate, FCR and PER for the birds on the 2800 and 3000 ME (Kcal/Kg) diet than those on the 2600 energy diet (Table 3). While the consumption of calorie, protein and water increased (P<0.05) with increment in energy level, CF intake, water intake: weight gain, faecal output and mortality rate were not affected (P>0.05) by the varying energy levels. However, feed intake was higher (P<0.05) at 2600 ME (Kcal/Kg) diet than at the other energy levels. The water: feed intake for the medium and high energy levels were uniform (P>0.05) and wider (P<0.05) than the ratio for the low energy level because of the higher water intake at the former energy levels.

The interaction effect of varying levels of CF and ME was in accordance with the main effects of the individual variable factors on the response criteria (Table 4). Birds fed 8 and 12% CF at 2800 and 3000Kcal ME/Kg diet had the highest (P<0.05) weight gain which, was closely followed by those on 8 and 12% CF at 2600 ME (Kcal/Kg) diet, while those fed 4% CF at all energy levels had the least (P<0.05) weight gain. Feed intake was nearly uniform across the treatment groups with varying CF levels within each energy level except diets D and G with the lowest feed intake. FCR was poorer (P<0.05) at the lowest energy level, irrespective of CF level, unlike on the medium and high energy levels while PER was generally uniform across the energy and fibre levels.

Table 1: Gross composition of experimental diets for broiler finishers (%)

	2,600 ME (Kcal/Kg)			**2,800** ME (Kcal/Kg)			**3,000** ME (Kcal/Kg)		
Feed ingredients	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Maize (2%CF)	46	39	20	48	38	26	43	30	21
Wheat offal (8.5%CF)	18	19	18	12	12	5	12	12	3
Rice offal (38%CF)	2	12	23	2	10	24	2	10	25
Palm kernel cake (17.5%CF)	3	2	3	5	10	5	5	10	4
Groundnut cake (5%CF)	14	15	18	13	12	18	12	12	18
Blood meal (1%CF)	4	4	4	6	6	6	8	8	8
Fish Meal (1%CF)	2	2	2	4	3	3	4	4	4
Palm oil	1	2	7	2	4	8	6	9	12
Sterilised sand	5	-	-	3	-	-	3	-	-
[a] Fixed Ingredient	5	5	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100	100	100
[b]Cost of feed (₦/Kg)	67.2	64.2	60.3	78.7	73.5	67.2	79.4	70.9	68.4
Calculated Fraction:									
Metabolisable Energy (kcal/kg)	2611.9	2621.9	2604.9	2808.3	2806.9	2813.3	2985.2	3015.0	2996.9
[b]Determined Fractions (%):									
Dry matter	90.3	90.1	90.1	90.2	90.4	89.0	90.1	88.2	88.4
Crude protein	17.7	17.8	17.7	19.5	19.4	19.3	20.1	20.1	20.2
Crude fat	4.44	6.45	11.4	5.41	7.52	12.6	8.45	11.7	15.4
Nitrogen – free extract	52.1	49.1	42.8	49.9	45.7	37.4	48.3	39.5	32.8
Crude fibre	3.95	7.68	11.80	4.05	7.88	11.85	4.00	7.75	11.9
Ash	12.4	12.5	12.6	12.4	12.7	12.5	13.2	13.1	13.1

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

[b]Means of triplicate determinations.

Interaction effect also indicated uniformity in the water: feed intake for the medium and high-energy diets, which were wider (P<0.05) than those of the low-energy diets. The water intake: weight gain ratios for the treatment groups except those on diets C and H were also uniform (P>0.05) and it was in the order of 7:1. Furthermore, interaction effect (Table 4), showed that feacal output increased as CF level increased while no mortality was observed.

Optimal growth performance was attained at lower feed cost per unit weight gain in broiler finishers fed diets containing 12% CF at 2800 and 3000 ME (kcal/kg) (diets F and I) at the calorie: protein ratio of 140:1. Diet E was equally adequate nutritionally but significantly costlier p<0.05) than diets F and I.

Table 2: Main effect of varying levels of dietary crude fibre on performance characteristics of broiler finishers

Performance parameters	Dietary crude fibre level (%) 4	8	12	± SEM
Initial body weight at 28 days (g/b)	746.7^{b}	804.5^{a}	734.7^{c}	3.17
Body weight at 56 days (kg/b)	1.89^{b}	2.07^{a}	2.02^{a}	0.02
Weight gain (g/b/d)	40.9^{b}	45.3^{a}	45.4^{a}	0.78
Feed intake (g/b/d)	143.2^{b}	146.4^{b}	155.2^{a}	1.65
Feed conversion ratio	3.51^{a}	3.25^{b}	3.44^{a}	0.06
Protein efficiency ratio	1.43^{b}	1.55^{a}	1.46^{ab}	0.02
Protein intake (g/b/d)	28.7^{b}	29.3^{ab}	31.1^{a}	0.28
Calorie intake (Kcal/b/d)	403.1^{c}	412.7^{b}	438.6^{a}	4.24
Crude fibre intake (g/b/d)	6.02^{c}	11.9^{b}	18.9^{a}	1.32
Water intake (ml/b/d)	296.3^{c}	301.4^{b}	308.5^{a}	2.22
Water: feed intake ratio	2.08^{a}	2.06^{a}	1.98^{b}	0.02
Water intake: weight gain ratio	7.25	6.47	6.64	0.11
Faecal output (g/b) at 46-48days	66.9^{c}	79.9^{b}	95.0^{a}	1.36

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

Table 3: Main effect of varying levels of dietary energy on performance characteristics of broiler finishers

Performance parameters	Dietary energy level ME (Kcal/Kg) 2600	2800	3000	± SEM
Initial body weight at 28 days (g/b)	724.4^{b}	776.4^{a}	776.9^{a}	3.17
Body weight at 56 days (kg/b)	1.95^{b}	2.02^{ab}	2.10^{a}	0.02
Weight gain (g/b/d)	43.6^{b}	44.7^{ab}	45.9^{a}	0.78
Feed intake (g/b/d)	151.9^{a}	147.7^{b}	145.9^{b}	1.65
Feed conversion ratio	3.50^{a}	3.30^{b}	3.20^{b}	0.06
Protein efficiency ratio	1.54^{a}	1.50^{ab}	1.48^{b}	0.02
Protein intake (g/b/d)	28.2^{b}	29.7^{ab}	31.1^{a}	0.28
Calorie intake (Kcal/b/d)	398.8^{c}	417.6^{b}	438.0^{a}	4.24
Crude fibre intake (g/b/d)	12.5	12.4	11.9	1.32
Water intake (ml/b/d)	292.4^{c}	303.2^{b}	310.5^{a}	2.22
Water intake: feed intake ratio	1.93^{b}	2.06^{a}	2.13^{a}	0.02
Water intake: weight gain ratio	6.74	6.80	6.82	0.11
Faecal output (g/b) at 46-48days	81.9	79.8	80.1	1.36

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

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

Performance parameters	2600			2800			3000 ME (K cal/Kg) diet			
	A 4	B 8	C 12%CF	D 4	E 8	F 12%CF	G 4	H 8	I 12%CF	± SEM
Initial 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}	842.9^{a}	713.2^{e}	8.90
Body weight at 56 days (kg/b)	1.82^{c}	1.89^{bc}	1.91^{bc}	1.93^{bc}	2.12^{ab}	2.06^{b}	1.93^{bc}	2.21^{a}	2.10^{ab}	0.06
Weight gain (g/b/d)	39.5^{c}	41.0^{bc}	42.6^{bc}	42.0^{bc}	46.1^{ab}	46.0^{ab}	41.2^{c}	48.9^{a}	47.5^{a}	1.56
Feed intake (g/b/d)	146.7^{abc}	149.5^{abc}	159.4^{a}	141.6^{c}	144.2^{bc}	157.4^{ab}	141.3^{c}	145.6^{abc}	150.7^{abc}	4.63
Feed conversion ratio	3.72^{a}	3.64^{a}	3.74^{a}	3.37^{ab}	3.13^{b}	3.41^{ab}	3.43^{ab}	2.98^{b}	3.18^{b}	0.17
Protein efficiency ratio	1.44^{ab}	1.46^{ab}	1.45^{ab}	1.47^{ab}	1.58^{a}	1.45^{ab}	1.37^{b}	1.61^{a}	1.47^{ab}	0.06
Protein intake (g/b/d)	27.3^{d}	28.0^{cd}	29.4^{bcd}	28.6^{cd}	28.9^{cd}	31.6^{ab}	30.1^{abc}	31.0^{ab}	32.1^{a}	0.79
Calorie intake(Kcal/b/d)	385.3^{e}	393.2^{de}	417.8^{abcde}	401.4^{cde}	406.9^{bcde}	444.4^{ab}	422.4^{abcd}	437.9^{abc}	453.7^{a}	11.9
Crude fibre intake (g/b/d)	6.08^{c}	12.09^{b}	19.31^{a}	6.04^{c}	11.96^{b}	19.19^{a}	5.93^{c}	11.83^{b}	18.22^{a}	3.71
Water intake (ml/b/d)	287.5^{b}	292.5^{b}	296.9^{ab}	296.3^{ab}	300.1^{ab}	313.3^{a}	305.2^{ab}	311.5^{a}	315.2^{a}	6.23
Water: feed intake	1.97^{abc}	1.96^{bc}	1.87^{c}	2.09^{ab}	2.08^{ab}	2.00^{abc}	2.16^{a}	2.14^{ab}	2.09^{ab}	0.06
Water intake: weight gain	7.28^{ab}	6.50^{ab}	6.44^{b}	7.05^{ab}	6.52^{ab}	6.82^{ab}	7.41^{a}	6.39^{b}	6.66^{ab}	0.31
Faecal output (g) at 46-48days	76.7^{cd}	81.3^{bcd}	87.7^{bc}	59.9^{f}	73.6^{de}	105.8^{a}	63.9^{ef}	84.8^{bcd}	91.44^{b}	3.82
[1]Cost of feed (₦/Kg)	67.2	64.2	60.3	78.7	73.5	67.2	79.4	70.9	68.4	-
[2] Feed cost /kg weight gain (₦)	249.9^{bc}	233.8^{cd}	225.5^{de}	265.1^{a}	230.0^{cd}	228.9^{de}	272.3^{a}	211.3^{e}	217.5^{de}	6.22

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

[1]Computed from Table 1.

[2] Obtained as product of feed conversion ratio and cost per kg diet.

Discussion

The determined values of crude protein among other proximate components fell within the range of recommended values (19 - 21%) for broiler finishers (5, 12). The calorie: protein ratio of 140:1 was close to the recommended ratios for broiler finishers (13).

The optimum growth performance achieved on the diets containing 8 or 12% CF at 2800 or 3000 ME (Kcal/Kg) revealed that moderate levels of dietary CF as a nutrient and adequate dietary ME are essential for broiler growth performance (4, 14, 15). Thus, the observed CF tolerance limit of 12% disagreed with earlier recommendations of 5% by (16). However, the observed 12% CF tolerance limit is close to the 8-10% CF reported by (17). The sub-optimum growth rate at 2600 ME (Kcal/Kg) diet irrespective of CF level is an indication that this energy level was inadequate (18*)* despite the close calorie: protein ratio in the test diets. This is at variance with the earlier recommendations of lower dietary ME concentration for the animals reared in the tropical environment (1, 19).

Within the range of CF levels in this study, growth stimulant but not growth depressant effect was observed, thereby negating the frequent implication of CF as a growth depressant beyond 5%. The effects of CF as a growth depressant or stimulant occur via several mechanisms such as increased or reduced consumption of feed and enhancement or impairment of digestion and absorption of nutrients. Expectedly, broiler finishers were able to cope with more CF than the broiler starters (6), which is in agreement with the reports of (20, 21). This assertion is attributed to the better development of the gut in broiler finishers. This might explain why the broiler starters could cope with 8% CF (6) while the broiler finishers could tolerate up to 12% CF at the optimum dietary ME levels, ranging from 2800 to 3000 ME (Kcal/Kg) diet

The dilution effect of dietary CF (15, 22) was responsible for the observed increment in the consumption of feed within the gut capacity of the birds up to the optimum CF levels at the finisher phase, as reflected in the optimum weight gain. The increased feed intake assisted the birds to satisfy the requirements for nutrients and energy as reflected in the similarity in the intakes of nutrients and calorie in agreement with the reports of (4, 22). Similarly, the calorie, protein and water consumption of the birds increased as the dietary energy level increased, thereby maximizing weight gain at 2800 and 3000 ME (Kcal/Kg). Birds usually consume more feed when the dietary energy is not enough (18, 23).

The increased water intake as dietary CF increased is in agreement with (6) and these might be as a result of hydration properties of soluble and insoluble fibre components of the diets (25). Water has high latent heat of vaporization, with 540 calories of heat absorbed per gram of water, hence, the increase in water intake as level of dietary energy increased was for the birds to be able to dissipate excess heat by vaporization as in panting and defaecation. This pattern of water consumption has been reported in the cockerels (24) and in broilers (15, 21). Although water intake of the birds increased generally as dietary CF and ME levels increased, the water intake: weight gain was nearly uniform at the finisher phase as it was in the starter phase of broiler production (6). This implies that water deprivation in the birds could jeopardize growth performance on the basis of the ratio of water intake to feed intake (which is of the order of 2-3:1) for the poultry birds (7). The ratios obtained for the treatment groups are in concurrence with those ratios reported for the cockerel chicks (7) and broilers (6). The water: feed intake ratio was similar across treatment diets (2:1) irrespective of the CF level, while the ratio became wider (2-3:1) as dietary ME level increased. The protein efficiency ratio was generally similar across diets, which shows the effect of age of the broilers in converting dietary protein to weight gain, with older age being an advantage in the utilization of protein in the low-energy diets at all CF levels as well as the 8 and 12% CF diets at the medium and high energy levels. Adaptation or better development of the gut in the broiler finishers might have assisted them to utilize fibre efficiently without interference with dietary protein utilization. The optimum values of FCR for the CF and ME levels followed the same pattern, in support of the 8 to 12% CF level in the broiler finisher diet at the dietary ME level, ranging from 2800 to 3000 ME (Kcal/Kg)

The faecal output revealed the purgative or bulking effect of CF, with the largest quantity of faeces voided by the birds on the 12% CF at all the energy levels similar to observations by (15). Faster passage of digesta and poor bacterial fermentation of insoluble fibre in the gut is responsible for impaired digestion and absorption resulting in larger faeces excreted. The resultant effect of impaired digestion and absorption is the loss of nutrients via faeces as CF level increased (20, 26). The feed cost reduction per kg live weight gain at 12% CF level in the medium and high energy diets is concordant with the report of (6) for the broiler starters at 8% dietary CF level, implying that CF can be exploited to reduce feed cost at the optimal level without adverse effect on performance.

Conclusion and Application

1. There was no mortality during the experimental period, suggesting the level of CF used had no negative implication on health status of the birds.
2. Dietary ME levels of 2800 and 3000Kcal/kg diet proved adequate for finishing broiler chickens while 2600 ME (kcal/kg) diet was not.
3. The dietary CF levels of 8 or 12% was tolerated at finishing phase in this study and that showed that older broiler chickens have the ability to tolerate higher dietary CF compared to the younger chicks.
4. Growth stimulant but not growth depressant effect of CF was observed within the range of CF levels fed, which showed that CF can be tolerated at levels beyond 5%.
5. Higher dietary CF levels decreased feed cost per kg live weight gain, while higher dietary energy levels increased feed cost per kg live weight gain. Thus, 12% CF diet at

3000ME (kcal/kg) appeared adequate for optimal performance in broiler finishers at minimal feed cost per kg live weight gain.

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