

Effects of feeding four varieties of *Sorghum bicolor* as replacement for maize on growth performance of broiler chicks in Kaduna state

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Target audience: Poultry farmers, Extension workers and Researchers.

Abstract

The pressure on maize by feed industries and other industries has been increasing worldwide and maize has remained the major energy source in compounded diets of poultry ration which requires attention for alternative energy feed stuff for poultry due to cost and varying climatic changes. A study was carried out to evaluate the effects of feeding four varieties of *Sorghum bicolor* on growth performance of broiler chickens in Zaria, Kaduna state, Nigeria. Two hundred and twenty five (225) Arbor acre chicks were randomly distributed into five dietary treatments after three days adjustment period using the complete randomized design (CRD) as follows, T₁ - maize, T₂ - Samsorg-14, T₃ - Samsorg-40, T₄ - Samsorg-17 and T₅ - KSV-15 in replacement for maize (T₁) on the performance of broiler chickens. Each treatment had forty-five (45) birds per treatment allotted into three (3) replicates containing fifteen (15) birds per pen, which lasted for four weeks. Data were subjected to analysis of variance (ANOVA) and significant ($P < 0.05$) differences among treatments were compared using the Tukey's test. The result at the starter phase showed that chicks fed T₁ and T₂ were significantly ($P < 0.05$) higher in final body weight, average daily weight gain and had better feed conversion ratio and feed cost/kg gain than birds fed T₃, T₄ and T₅ diets. In conclusion total replacement of Samsorg-14 (T₂) for maize (T₁) in broiler chicks' diet had no negative impact on performance at the starter phase, therefore Samsorg-14 can be incorporated in the diets of broiler chicks at 100%.

Key words: Broiler chicks, Sorghum varieties, growth performance

Description of problem

Cereal grains are the major sources of energy in poultry diets in the tropics (1). Common cereals used in tropical countries include maize and guinea corn (sorghum) and to a less extent, millet and wheat (2). Cereals as an energy source constitutes between 45 and 70 % of the energy in poultry, swine and rabbit diets (2). The demand for cereals as food, feed and industrial raw materials is increasing due to population explosion in developing countries and short falls in cereals production in several developed countries. It is well established that the constantly growing

worldwide demand for low-cost protein of animal origin has led to an increase for broiler meat due to its fast growth rate, tenderness and taste when compared with other meat types (3).

Maize has remained the chief energy source in compounded diets and constitutes about 50% of poultry ration (4). Pressure on maize, wheat and recently cassava has been on the increase worldwide with emphasis being placed on export and other diversified uses, mostly in flour based foods and ethanol production as an alternative source of fuel. Based on the above trend there is the need for

diversification of energy feed stuff for poultry and the prospects of increasing maize output to a magnitude that will satisfy both human and animal requirements are quite slim as reported by (5). Therefore there is a need to reduce over dependency on the use of maize in poultry diets especially during seasons of low productivity, as a result of low rainfall and global warming to prevent the poultry industry from feed challenges such as inflation in prices of major cereals that is used up to 50-60% in poultry diets that could affect the income of farmers and productivity.

Nigeria was ranked the second largest producer of sorghum in the world with about 6550 million tonnes of grains produced from 5.4 million hectares of land (6). Sorghum is an indigenous cereal crop of Africa; it has the ability to tolerate drought, soil toxicities and temperature extremes effectively than other cereals. It is cultivated worldwide in warmer climate and can be grown on poor soil and in drier conditions than maize (2). Sorghum grain is probably the next alternative to maize in poultry feed (7).

Several poultry feeding trials have reported that sorghum can replace maize as energy source in the diets of broiler chickens without adverse effects on growth rate or feed conversion ratio (8;9). The metabolizable

energy content of sorghum is 3288 (10). Sorghum grains contain about 92.50 % dry matter, 3270.00 kcal/kg metabolizable energy, 9.50 % crude protein, 2.55 % ether extract, 2.70 % crude fibre, 1.25 % ash and 76.60 % nitrogen free extract (NFE) (7). Its protein is slightly higher than maize but as with most cereals it is deficient in lysine and tryptophan (7).

This study was therefore designed to evaluate the effects of feeding four varieties of *Sorghum bicolor* (Samsorg-14, Samsorg-40, Samsorg-17 and KSV-15) in Kaduna state on the performance of broiler chickens.

Materials and Methods

Experimental site

The experiment was conducted at the Poultry Unit, Department of Animal Science Teaching and Research farm, Ahmadu Bello University, Zaria, Kaduna State, which is within the Northern Guinea savannah zone of Nigeria on latitude 11^o14'14"N and longitude 7^o38' 65" E at an altitude of 610 m above sea level (11).

Sources of sorghum

The sorghum seeds used for this study were obtained from Samaru and Giwa in Kaduna State. The varieties were:

S/N	Colour	Scientific name	IAR name	Local name
1	White sorghum	<i>Sorghum bicolor</i>	Samsorg -14	Fara fara
2	Cream sorghum	<i>Sorghum bicolor</i>	Samsorg – 40	Mori
3	Yellow sorghum	<i>Sorghum bicolor</i>	Samsorg – 17	Kaura
4	Red sorghum	<i>Sorghum bicolor</i>	KSV – 15	Jandawa

Experimental birds

Two hundred and twenty – five Abor-acre broiler chicks were obtained from Zamfy Farms, Ilemo, Kwara State, Nigeria.

Laboratory analysis

The chemical compositions of the raw sorghum varieties and maize and experimental diets were carried out in the Animal Science Biochemistry Laboratory, Ahmadu Bello

University, Zaria according to the method of (12). The gross energy of maize and sorghum was determined using the Gallen Kamp Ballistic oxygen bomb calorimeter. Proximate compositions of all the diets were determined according to the method of (12).

Estimation of energy content of the sorghum varieties

The Metabolizable energy was estimated for diets containing sorghum and maize, based on the proximate composition equation outlined by (13), $ME \text{ (kcal/kg)} = (35.0 \times CP) + (81.8 \times EE) + (35.5 \times NFE)$

Anti-nutritional factors determination

The different anti-nutritional factors contained in the four different sorghum varieties were carried out in the Animal Science Biochemistry Laboratory, Ahmadu Bello University, Zaria and were determined as contained in Table 3 using the following procedures: Total Tannin in sorghum grains was determined as described by (12). The total oxalate and phytate of the sorghum samples were determined using the method described by (14). The saponin content of the sorghum samples was determined using the method described by (15).

Experimental diets

Five experimental diets were formulated within (23 % CP at starter phase and 21 % at finisher phase) and within (2900 Kcal/kg in the starter phase and 3000 Kcal/kg in the finisher phase) to meet the standard requirements of broilers chickens in the tropics (16: 2).

The control diet had 0 % sorghum while the four other diets had the different sorghum varieties milled and included at 100 % replacement for maize at the starter phase in the diet (Table 1).

Design and management of experimental birds

At the starter phase two hundred and twenty five (225) four days old broiler chicks of mixed sexes were used. The birds were weighed at the beginning of the experiment and allotted into five different dietary treatments after three days in a completely randomized design (CRD). The birds were housed in deep litter pens; each treatment group had total number of forty five (45) birds in three replicates of 15 birds per pen. Routine vaccination and medications were given as at when due. Feed and water were provided *ad libitum*.

Growth study

Growth parameters were measured and calculated, these included final body weight, weight gain, feed intake, feed to gain ratio and feed cost per kg gain.

Broilers were weighed at the beginning of the experiment and weekly thereafter, feed and water was provided *ad libitum* daily. Left over feed was weighed and subtracted from the total feed supplied for the week to obtain feed intake per week. The study lasted for four weeks and mortality was recorded as it occurred and calculated in percentages.

Statistical analysis

All data obtained from the study were subjected to analysis of variance (ANOVA) using general linear model procedure of SAS (17). Significant levels of differences among treatment means were determined using the Turkey test (18) to separate the means. The statistical model for all the four experiments were as follows:-

$$X_{ij} = \mu + t_i + e_{ij}$$

where X_{ij} = any observation made in the experiment

μ = the population mean

t_i = effect due to treatment added or treatment effect

e_{ij} = random error

Results

Chemical composition of maize and four sorghum varieties fed to broilers at the starter phase are presented on Table 2 and 3 respectively.

The metabolizable energy for maize was 3470.60kcal/kg, dry matter content 94.22%, crude protein 8.78 %, crude fibre 2.68 %, ether extract 4.00%, ash content 4.65% and nitrogen free extract (NFE) 79.89 %.

The chemical composition for raw sorghum varieties are as follows; Samsorg-14 had a metabolizable energy of 3412.69 kcal/kg, dry matter content (92.52%), crude protein (9.14%), crude fibre (3.87%), ether extract (3.29%), ash (4.66%) and nitrogen free extract (79.54%).

Samsorg-40 had a metabolizable energy of 3391.31kcal/kg, dry matter content (91.66%) crude protein (10.16%), crude fibre (3.84%), ether extract (3.56%), ash (5.37%) and nitrogen free extract (77.31%). The

metabolizable energy of Samsorg-17 was (3486.15kcal/kg), dry matter content (93.66%), crude protein (9.49%), crude fibre (2.56%), ether extract (4.06%), ash content (4.00%) and NFE (79.49%). KSV-15 had a metabolizable energy of 3379.39kcal/kg, dry matter (91.39%), crude protein (10.80%), crude fibre (3.91%), ether extract (3.11%), ash (4.42%), NFE (77.38%).

The result showed that maize had higher gross energy, metabolizable energy, ether extract and nitrogen free extract, but lower crude protein and crude fibre compared to sorghum grains, but Kaura had comparable % CF and EE to that of maize. Samsorg-17 and Samsorg-14 had higher ME when compared to Samsorg-40 and KSV-15 grains which were least among the sorghum varieties. The ash content in maize was comparable to raw Samsorg-14, Samsorg-17 and KSV-15 sorghum grains, while raw Samsorg-40 grains had higher ash content than maize.

Table 2: Chemical composition of maize and raw varieties of *Sorghum bicolor* grains

Parameter	ME (Kcal/kg)	% DM	% CP	% CF	% EE	% ASH	% NFE
Maize (white)	3470.60	94.22	8.78	2.68	4.00	4.65	79.89
Samsorg-14	3412.69	92.52	9.14	3.87	3.29	4.66	79.54
Samsorg-40	3391.31	91.66	10.16	3.84	3.56	5.37	77.31
Samsorg-17	3486.15	93.66	9.49	2.56	4.06	4.00	79.49
KSV-15	3379.39	91.39	10.80	3.91	3.11	4.42	77.38

Table 3: Chemical composition of broilers starter diets containing four varieties of raw *Sorghum bicolor* (0-4wks)

Parameters	T ₁ (Control)	T ₂ (Samsorg-14)	T ₃ (Samsorg-40)	T ₄ (Samsorg-17)	T ₅ (KSV-15)
Dry matter (%)	92.11	92.67	93.12	91.66	92.88
Crude protein (%)	23.38	23.88	24.19	24.81	24.50
Ether extract (%)	5.03	5.28	5.43	5.59	5.68
Crude fibre (%)	2.88	2.46	1.67	3.48	2.44
Ash (%)	6.90	8.75	7.94	8.65	6.67
NFE (%)	61.81	59.63	60.00	59.28	59.67
ME(Kcal/kg)	3424.01	3384.57	3420.82	3430.05	3440.41

NFE: Nitrogen Free Extract ME-Metabolizable energy

Levels of Anti- nutritional factors contained in four varieties of sorghum are presented in Table 4.

The result shows that sorghum varieties contains anti-nutritional factors such as phytic acid within 0.66 - .74mg/100ml, tannin 0.23-0.33mg/100ml, saponins 0.42-.60 mg/100ml and oxalate 0.22-0.26 mg/100ml.

The result showed that Samsorg-40,

Samsorg-14, Samsorg-17 and KSV-15 were significantly (P<0.05) different in the levels of anti-nutritional factors. The phytic acid content was highest in KSV-15 and Samsorg-14 and both grains had the same values (0.74 mg/100ml) and were significantly (P<0.05) different from Samsorg-40 and Samsorg-17 grains.

Table 4: Anti-nutritional factors of four varieties of raw *Sorghum bicolor*

Parameters	Raw Sorghum Varieties				
	Samsorg-14	Samsorg-40	Samsorg-17	KSV-15	SEM
Phytic acid (mg/100ml)	0.74 ^a	0.71 ^b	0.66 ^c	0.74 ^a	0.005
Tannin (mg/100ml)	0.26 ^b	0.25 ^b	0.23 ^c	0.33 ^a	0.005
Saponin (mg/100ml)	0.48 ^b	0.51 ^b	0.42 ^b	0.60 ^a	0.004
Oxalate (mg/100ml)	0.26	0.22	0.22	0.25	0.004

The Tannin content for the four varieties of sorghum grains showed that KSV-15 had the highest value (0.33mg/100ml) and was significantly (P<0.05) different from Mori (0.25mg/100ml), Samsorg-14 (0.26mg/100ml) and Samsorg-17 having the least (0.23mg/100ml). There were no significant (P>0.05) differences between Samsorg-40 and Samsorg-14 in terms of tannin content.

The Saponin content was significantly (P<0.05) higher in KSV-15 (0.60 mg/100ml) compared to the other sorghum grains. Samsorg-17 had the least saponins and oxalate values while Samsorg-14 had the highest oxalate value.

Growth performance

The effect of feeding four varieties of raw sorghum (Samsorg-14, Samsorg-40, Samsorg-17 and KSV-15) in total replacement of maize on the performance of broiler chickens is presented in Table 5. The result showed significant (P<0.05) differences in final weight, average daily weight gain, feed intake, cost /kg gain and feed conversion ratio for broiler chicks fed four varieties of sorghum in this study compared to birds fed the maize diet. Birds fed maize diet had the best growth performance, although birds fed Samsorg-14 (T₂) statistically showed no significant (P>0.05) difference from birds fed the control diet (T₁-100% maize inclusion) in terms of final weight and daily weight gain and in addition had the least cost / Kg gain.

Table 5: Performance of broiler chickens fed four varieties of raw *Sorghum bicolor* (0-4weeks)

Parameters	Treatments					SEM
	T1	T2	T3	T4	T5	
Initial weight (g)	73.33	73.33	73.33	73.33	73.33	0
Final weight (g)	917.14 ^a	869.50 ^a	822.10 ^b	842.74 ^b	836.83 ^b	27.91
Average Daily weight gain (g)	30.13 ^a	28.44 ^a	26.73 ^b	27.48 ^b	27.27 ^b	0.99
Average Daily feed intake (g)	56.96 ^a	53.33 ^b	57.06 ^a	62.52 ^a	52.37 ^b	2.89
Feed conversion ratio	1.89 ^a	1.87 ^a	2.14 ^b	2.28 ^b	1.93 ^a	0.07
Feed cost ₦/ kg gain	158.50 ^a	156.54 ^a	179.46 ^b	191.20 ^b	186.13 ^b	6.35
Mortality (%)	2.23	6.67	6.67	4.44	2.22	2.67

SEM = Standard error of means

^{a,b} Means on the same row with different superscripts are significantly (P<0.05) different.

T1- Control, T2-Samsorg-14, T3-Samsorg-40, T4-Samsorg-17, T5- KSV-15

Discussion

The result for the metabolizable energy of maize was within the range of 2617- 3516 as reported by (19) and 3451.18 kcal/kg as reported by (20) but the value was lower than 3510 kcal/kg as reported by (2), the reason could be due to varietal difference, soil, environmental and storage conditions in which maize was raised which could affect the metabolizable energy values (7). The dry matter content of maize obtained in this study was similar to the value (94.10 %) as reported by (20). The crude protein content of maize recorded in this study was within the range of 8 - 9 % crude protein as reported by (21) and similar to (8.8%) as reported by (2).

The crude fibre value for maize obtained in this study was 2.68 % which was similar to the reports by (21); (22) but differ from the findings of (2) and (20) who reported 2.1 and 3.2 % respectively. The ether extract value (4.00 %) was similar to the findings of (21) and (2).

The ash content for maize was higher (4.65 %) compared to (1.3, 1.5 and 1 %) as reported by (21); (22); (2). The nitrogen free extract of 79.89 % for maize was higher than 75.80 and 80.6 % as reported by (2) and (20) respectively. The differences observed in the

values of the proximate composition varied, which could be as a result of the variety of maize used, soil nutrients and storage conditions (7).

The metabolizable energy values for four sorghum varieties were within the range of 2617 to 3516 kcal /kg as reported by (19) and 3451.18 kcal / kg as reported by (20) for yellow and white sorghum varieties. The dry matter content for the four sorghum varieties ranged from 91.39 - 93.66 % which agreed with the findings by (2) ; (20) while (23) reported the same range for Samsorg-17.

The crude protein result for the four sorghum varieties ranged from 9.14 – 10.80 % crude protein. The crude protein results supported the reports by (2); (7); (20) for white and yellow sorghum and (8.53 – 9.27 % CP) for yellow and red sorghum as reported by (23).

The crude fibre content for four varieties of *Sorghum bicolor* ranged from 2.56 % - 3.91 %, the results supported the findings by (2) and (7) they reported values of 2.70 %, the value fell within the range obtained in this study despite the varietal differences. 20 and 23 reported higher values of crude fibre ranging from 4.69 - 4.78 % and 3.47 - 4.71 % respectively. The results obtained for ether

extract agreed with the reports by (20) that ether extract for sorghum ranges from 3.19 % - 3.82 % but the result did not conform to the reports by (2) and (7) who reported that ether extract has a value of 2.50 and 2.55 % respectively.

The ash content for four sorghum varieties were higher than (1.31 – 1.46 %) as reported by (2); (23) for yellow and red sorghum, (20) reported (1.86 – 1.89 %) for white and yellow sorghum.

The nitrogen free extract (NFE) for the four sorghum varieties ranged from 77.31% - 79.54 %, these values were within the values reported by (2); (7); (20) for NFE in sorghum. The variation in some of the chemical values of *Sorghum bicolor* from other authors could be due to environment, soil and variety as reported by (7; 24; 25).

The result confirmed the reports by (16) and (2) that sorghum had lower metabolizable energy (ME), lower dry matter and ether extract but higher crude protein than maize. The percent dry matter (DM), ether extract and nitrogen free extract (NFE) were higher in maize compared to sorghum, this may be responsible for the higher value of ME (kcal/kg) in maize compared to the values recorded for raw sorghum as reported by (20).

Levels of Anti- nutritional factors contained in four varieties of sorghum shows that KSV-15 had the highest levels of phytic acid, tannin and saponin followed by Samsorg-14 and Samsorg-40. Oxalate levels did not show any significant ($P>0.05$) difference in four sorghum varieties used for this study. The least values of anti- nutritional factors was observed with Samsorg-17 which agreed with the reports by (26) and (27) that yellow coloured sorghum (Kaura) had the least anti-nutritional factors compared to white and red coloured sorghum (Farafara and Jandawa) the same author reported that red coloured sorghum is high in tannin content compared to other sorghum varieties mentioned above. The

result for phytic acid and oxalate did not agree with the reports by (27) that red coloured sorghum(KSV-15) had higher phytic acid and oxalate than white coloured sorghum (Samsorg-14).

Performance of broiler chicks fed different sorghum varieties showed that there was significant ($P<0.05$) differences in final weight, average daily weight gain, feed intake, cost /kg gain and feed conversion ratio for broiler chicks fed four varieties of sorghum in this study compared to birds fed the maize diet this result agreed with the reports by (28) and (20) that birds fed sorghum diets performed significantly ($P<0.05$) lower than birds fed maize diets. Although birds fed Samsorg-14 (T_2) at the starter phase showed no significant ($P>0.05$) differences in terms of final weight and daily weight gain from birds fed the control diet (T_1 -100% maize inclusion) this could be due to anti-nutritional factors such as tannin, phytic acid and oxalate which affected digestibility of nutrients and hampered nutrient assimilation resulting to poor performance (24).

The feed intake of birds fed Samsorg-17 diet (T_4) were not significantly ($P>0.05$) different from birds fed the control diet (T_1) and the results were similar to the reports by (8) and (20) that feeding sorghum varieties with low tannin levels did not affect feed intake significantly. The lower feed intake in birds fed Samsorg-14 (T_2) supported the findings by (20; 24;) that broilers fed white coloured sorghum had lower intake as a result of oxalate present in the grains which affected the feed intake and utilization, oxalates form complexes with minerals particularly calcium there by making them unavailable to the body and causes irritation of the gut resulting in lower feed intake due to inhibiting of protein and energy lowering utilization in broiler chickens. voluntary feed intake of birds are usually affected by anti-nutritional factors because of increase hepatic metabolism of

nutrients as reported by (31) not because of astringent taste as reported by (20) since birds have poor taste buds reported by (32) which is similar to birds fed KSV-15 diets (T₅) which has high tannin contents. According to the report of (24) tannin is associated with reduction in apparent metabolizable energy thereby affecting starch digestibility and voluntary feed intake and affecting performance in younger birds (14-21 days).

The significant (P<0.05) differences observed in the feed conversion ratio for birds fed four different sorghum varieties does not totally support the findings by (20) that birds fed sorghum diets had lower or poor feed conversion ratio as a result of lower feed intake but rather it could be as a result of lower crude protein intake, metabolizable energy and anti-nutritional factors impairing their availability in the diet which depressed nutritional digestion, absorption and utilization in birds, as the case is in birds fed Samsorg-40 (T₃) and Samsorg-17 (T₄) diets. as reported by (28 ; 20) that birds fed Samsorg-17 (short Kaura) had higher feed intake and higher FCR compared to birds fed maize (T₁) and Samsorg-14 (T₂) diets respectively.

The cost/kg gain were higher for birds fed T₃, T₄, T₅ (Samsorg-40, Samsorg-17 and KSV-15 diets) when compared to birds fed the control diet Maize (T₁). The results supported the findings by (20) that birds fed sorghum diets had higher feed cost/kg gain compared to birds fed maize diets. Birds fed T₂ (Samsorg-14) had similar results with birds fed maize diets (T₁), the result did not support that findings by (20) that birds fed white sorghum had a higher feed cost/kg gain than birds fed maize diets (T₁).

There were mortality during the period of study in all the dietary treatments at the starter phase which was during the first week due to cold stress and the results of mortality showed no significant differences which supported the findings by (20) and (30) respectively that

birds fed sorghum diets (white, yellow and red coloured sorghum) were not significantly (P>0.05) different in terms of percentage mortality.

Conclusion and Application

Based on this study, it is concluded that;

1. 100 % replacement of maize for Samsorg-14 did not affect the performance of broiler chicks at the starter phase and so can be incorporated in broiler chick diets without any negative effect on performance, growth and cost of production.
2. 100 % replacement of maize for Samsorg-40, Samsorg-17 and KSV-15 did not improve the performance of broiler chickens at the starter phase due to high anti-nutritional factors.
3. The results also revealed the importance of knowing the proximate composition and anti-nutritional content present in different sorghum varieties before incorporating it as a sole energy source in broiler chick diets to avoid toxic effects.
4. There is need for sorghum breeders to improve the local varieties of sorghum in terms of anti-nutritional contents in order to benefit the poultry industry.
5. Processing methods could be incorporated in feed industries to improve the value of sorghum varieties

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