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Performance of Broiler Chickens Fed Baobab, Amaranthus and Tiger Nut during a Hot-dry Season

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Authors' contributions

This work was carried out in collaboration between all authors. Author EOO designed the study, wrote the protocol and wrote the first draft of the manuscript. Author OBR managed the literature searches. Authors HWA and MSA managed the analyses of the study. Author AS performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated effects of baobab pulp *(Adansonia digitata), Amaranthus hybridus* and tiger nut *(Cyperus esculenthus)* on growth performance, cost-benefit indices and nutrient retention of heat-stressed broilers. The test ingredients were crude sources of vitamins A, C and E functioning as anti-stress for broilers during a hot-dry season. A total of 240 unsexed broiler chicks were used for the study in a completely randomized design (CRD), which lasted for 8 weeks. The birds were allotted to six treatments (each contained 40 chicks) of four replicates each. Test ingredients were included in the starter and finisher diets at 1%. Diet 1 (T_1) served as the control. T_2, T_3, T_4 and T_5

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contained synthetic vitamin C, baobab pulp, amaranthus and tiger nut seed respectively. T_6 contained 0.3% each of baobab, amaranthus and tiger nut. Results from the study revealed that there were significant (P<0.05) differences in the performance indices and the nutrient retained by the birds. Broiler chickens fed baobab pulp (crude source of vitamin C, T_3) had significantly more profit (P<0.05), better final body weight (P<0.05) and crude protein retention (P<0.05) than those fed amaranthus (T_4), tiger nut (T_5) and the mixture of the test ingredients (T_6). Feed conversion ratio was at the best (1.58) in T_3 while T_5 gave the worst (1.64) at 4th week. Birds fed T_1 gave the best (1.07) feed conversion ratio while T_4 had the worst (1.26) at 8th week. T_2, T_3 and T_5 had the least (10%) mortality compared with those fed control diet (T_1), amaranthus (T_4) and the mixture (T_6). In conclusion, the study showed that baobab pulp could replace synthetic vitamin C as antioxidant based on growth performance of broilers and its accrued profitability during a hot-dry season in the tropics.

Keywords: Performance; broiler; baobab pulp; amaranthus; tiger nut seed.

1. INTRODUCTION

Poultry production is a part of the livestock industry and the fastest means of increasing animal protein supply thus, holding the greatest promise of bridging the prevailing wide animal protein gap in Nigeria through its meat and eggs [1]. It's rather unfortunate that this industry faces problems of inadequate and expensive feedstuffs as well as heat stress, particularly during dry season. Heat stress is so important because all classes of poultry are susceptible to it. High ambient temperature and high relative humidity prevailing in the micro-environment of the poultry house in the tropics are unfavourable for efficient poultry production [2]. The result is that the full genetic potential of the birds is often not achieved. Therefore, efforts should be geared towards reducing or alleviating the problem.

Many studies had been carried out to ameliorate heat stress in broilers especially in the tropics. Oruseibio and Alu [3] supplemented synthetic vitamin C in the diets of broiler chickens and reported better body weight gain, feed intake, feed conversion ratio and lowered percentage mortality. Such beneficial effects were reported by [4] in broiler chickens when vitamins A, C and E were supplemented in the diets. The problem in using synthetic vitamins in broiler diets is that their costs add to the overall cost of production which eventually increases the costs of broiler products in the market. Also, the problem of availability of these vitamins to farmers in rural areas is another concern. Therefore, there is a need to look inward for cheap and locally available crude sources of these vitamins. Promising amongst the natural sources of the vitamins are Baobab pulp (*Adansonia digitata*, a natural source of vitamin C), *Amaranthus hybridus* (a natural source of vitamin A), and Tiger nut (*Cyperus esculentus*, a naural source of vitamin E). Manfredini et al. [5] reported that Baobab pulp was high in vitamin C, and [6] reported that its content ranges from 169-500 mg/100 g. The latter author [6] also reported that the pulp is rich in both calcium and phosphorus. The anti-nutrients present in baobab pulp, *Amaranthus hybridus* leaves and tiger nut tubers are phytate, tannin, saponin, oxalate and cynogenic glycosides. Amaranthus was reported to be an important source of vitamins, especially vitamin A [7] and it was also very rich in minerals and an excellent source of amino acids [8]. Although [8] reported that the leaves contained anti-nutrients, but [9] reported that they are within tolerable limits and can be detoxified by soaking, boiling or frying. Tiger nut is rich in minerals like phosphorus and potassium, and in vitamins like E and C [10]. The tubers are also rich in edible oil which can be used for cooking and in making soap [11]. This study, therefore, investigated the effects of these natural sources of vitamins A, C and E in the diets of broilers vis-à-vis their performance indices, nutrient retention and cost implication of using them during a hot-dry season.

2. MATERIALS AND METHODS

2.1 Site of Experiment

The study was carried out at the Poultry Unit of the Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, Nigeria. The state is situated between latitudes 12° – 13°58'N and longitudes 4°8' – 6°54'E [12]. The temperature is generally high with annual mean of about 38°C, and it shared border with Niger Republic to the North.

2.2 Experimental Diets

A total of 6 experimental diets were formulated using Pearson Square Method, in a way that the control diet (T_1) had no industrial vitamin C. Baobab pulp, amaranthus leaf and tiger nut were included in both the starter and finisher diets (Tables 1 and 2 respectively). Diets in T_2 contained 1% industrial vitamin C. The diets in T_3, T_4 and T_5 contained 1% each of baobab pulp, amaranthus and tiger nut respectively. T_6 contained a mixture of 0.3% each of baobab pulp, amaranthus and tiger nut.

2.3 Management of Experimental Birds

A total of 240 day-old broiler chicks (Anak strain) were randomly allotted into 6 dietary treatment groups in a completely randomized design. Each treatment group contained 40 chicks of four replicates (ten birds per replicate). The chicks were brooded for a period of 2 weeks during the hot-dry season. The birds were housed, immediately after brooding, in an open-sided, dwarf walled pen for a period of eight weeks. Normal routine and management practices as outlined for the tropics by Oluyemi and Roberts [13], were put to use during the study. Feed and water were provided *ad libitum*. All necessary vaccinations and medications were given to the experimental birds as at when due.

2.4 Data Collection

Data were collected on performance indices – body weight gain, feed intake, feed conversion ratio and mortality (Table 3). Also, data were collected on nutrient retention and cost-benefit indices (Table 4). Cost-benefit indices were carried out based on the values of feedstuffs at the time of the experiment. The temperature within the pen was recorded thrice (8 am, 1 pm and 6 pm) daily and the means were calculated and recorded (Fig. 1). Nutrient retention studies were also carried out at the seventh week. Four birds per treatment were taken into a metabolic cage. The birds were allowed a three-day adjustment period and a day fast before the droppings were collected. They were weighed fresh and dried in an oven at 60°C for 48 hours. The dried droppings were ground and taken to Laboratory for proximate analysis.

Table 1. Ingredient composition of experimental broiler starter diets

Ingredients	Diets (%)					
	T_1	T_2	T_3	T_4	T_5	T_6
Maize	55.00	55.00	55.00	55.00	55.00	55.00
Groundnut cake	30.00	30.00	30.00	30.00	30.00	30.00
Fish meal	3.00	3.00	3.00	3.00	3.00	3.00
Blood meal	3.00	3.00	3.00	3.00	3.00	3.00
Wheat offal	5.00	4.00	4.00	4.00	4.00	4.10
Bone meal	0.80	0.80	0.80	0.80	0.80	0.80
Limestone	2.50	2.50	2.50	2.50	2.50	2.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
*Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Industrial Vitamin C	-	1.00	-	-	-	-
Baobab pulp (Bao)	-	-	1.00	-	-	-
Amaranth. leaf (Ama)	-	-	-	1.00	-	-
Tiger nut (Tig)	-	-	-	-	1.00	-
Bao+Ama+Tig	-	-	-	-	-	0.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated:						
Crude protein (%)	23.39	23.23	23.23	23.23	23.23	23.25
ME (kcal/kg)	2881.21	2868.65	2868.65	2868.65	2868.65	2869.91

**Flomix® chick/starter premix composition per 1.25 kg: Vitamin A, 10,000,000I.U; Vitamin D3, 2,000,000I.U; Vitamin E, 10,000I.U; Vitamin K3, 2,000 mg; Vitamin B1, 500 mg; Vitamin B2, 5,000 mg; Vitamin B6, 300 mg; Vitamin B12, 10,000 mcg; Biotin, 100,000 mcg; Niacin, 25,000 mg; Pantothenic Acid, 10,000 mg; Folic Acid, 1,000 mg; Antioxidant, 125,000 mg, Manganese, 100,00 mg; Zinc, 50,000 mg; Cobalt, 250 mg; Iron, 40,000 mg; Copper, 6,000 mg; Iodine, 500 mg; Selenium, 100 mg; Choline chloride, 150,000 mg*

Table 2. Ingredient composition of experimental broiler finisher diets

Ingredients	Diets (%)					
	T_1	T_2	T_3	T_4	T_5	T_6
Maize	62.00	62.00	62.00	62.00	62.00	62.00
Groundnut cake	30.00	30.00	30.00	30.00	30.00	30.00
Fish meal	1.00	1.00	1.00	1.00	1.00	1.00
Blood meal	1.00	1.00	1.00	1.00	1.00	1.00
Wheat meal	3.00	2.00	2.00	2.00	2.00	2.10
Bone meal	0.80	0.80	0.80	0.80	0.80	0.80
Limestone	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25
*Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Industrial vitamin C	-	1.00	-	-	-	-
Baobab pulp (Bao)	-	-	1.00	-	-	-
Amaranth. Leaf (Ama)	-	-	-	1.00	-	-
Tiger nut (Tig)	-	-	-	-	1.00	-
Bao+Ama+Tig	-	-	-	-	-	0.90
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated						
Crude protein (%)	20.89	20.74	20.74	20.74	20.74	20.75
ME (kcal/kg)	2981.79	2969.23	2969.23	2969.23	2969.23	2970.49

**Flomix® grower premix composition per 1.25 kg: Vitamin A, 7,500,000I.U; Vitamin D3, 1,500,000I.U; Vitamin E, 7,500I.U; Vitamin K3, 2,000 mg; Vitamin B1, 500 mg; Vitamin B2, 4,000 mg; Vitamin B6, 200 mg; Vitamin B12, 10,000 mcg; Biotin, 50,000 mcg; Niacin, 15,000 mg; Pantothenic Acid, 6,000 mg; Antioxidant, 125,000 mg, Manganese, 100,00 mg; Zinc, 50,000 mg; Cobalt, 250 mg; Iron, 40,000 mg; Copper, 6,000 mg; Iodine, 500 mg; Selenium, 100 mg; Choline chloride, 50,000 mg.*

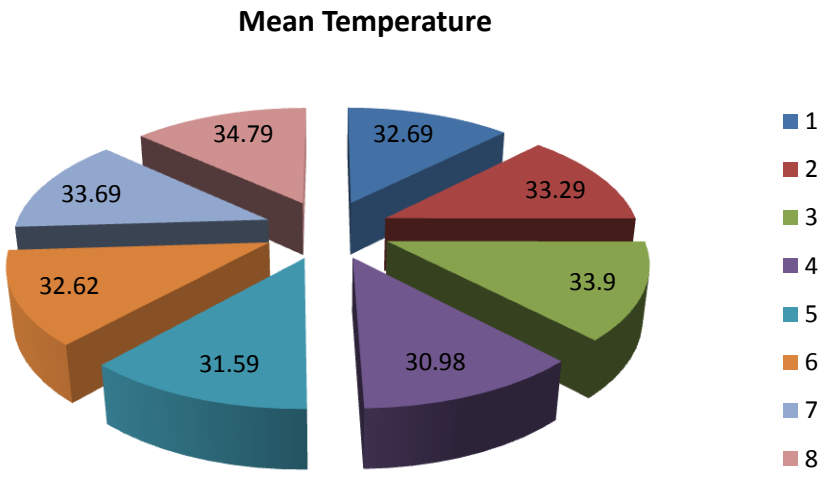

Fig. 1. Mean temperature (°C) during the study on weekly basis

2.5 Statistical Analysis

Data collected were analyzed by one-way analysis of variance using SAS [14]. Significant means were separated using Duncan option of the same software and a probability of 5% was considered significant.

3. RESULTS AND DISCUSSION

The effects of supplementing the test materials on the birds were shown in Table 3. At 4th week of the study, broiler chicks fed synthetic vitamin C diet in T_2 had the heaviest (660 g) final body weight whereas those fed diet containing the

mixture of baobab, amaranthus and tiger nut in T_6 had the lowest (572.50g). At 8th week of the study, broiler chickens in control (T_1) had the highest (1750g) final body weight while the least (1450g) was from birds fed diet T_4 and T_6. Significantly, higher daily feed intake ($P<0.05$) and weight gain were observed in broiler chicks fed control (T_1) and vitamin C ($T_{2)}$ diets than those fed other diets at 4th week of the study. Similar trend was also observed in feed intake at 8th week of the study. Also, daily weight-gain of broilers fed baobab pulp (T_3) and amaranthus (T_4) were better ($P<0.05$) than those fed tiger nut (T_5) and the mixture of the test ingredients (T_6) at 4 weeks. Mortality was at highest (30%) in the birds fed control diet (T_1), while the least was 10% for those fed synthetic vitamin C (T_2), Baobab (T_3) and Tiger nut (T_5). Feed conversion ratio was at the best (1.58) in T_3 at age four. Birds fed control (T_1) had the best (1.07) at 8th week and this resulted into the highest final weight recorded by the birds in the treatment. Average temperature throughout the period of study ranged from 30.98°C to 34.79°C (Table 3).

Birds fed vitamin C (T_2) and control diet (T_1) had similar performance at 4th week. Broiler chickens fed baobab pulp had comparable growth performance with that fed T_1. During times of environmental stress, according to [15], addition of ascorbic acid to birds' feed or drinking water alleviates many of the undesirable physical consequences of exposure like chronic adrenocortical activation, immune-suppression and weight loss. The above must have been responsible for the positive performance of birds fed baobab pulp (natural source of vitamin C). However, birds fed vitamin C (synthetic vitamin C), natural sources of vitamins A (amaranthus), E (tiger nut), and combination of the test ingredients, did not perform well when compared to those fed control diet (T_1) as far as the final weight is concerned. The lowest final body weight was obtained in birds fed diet containing mixture of baobab, amaranthus and tiger nut (T_6). This might be attributed to the saponins in the test ingredients which may have caused growth depression. This was in line with the report of [16] that saponins in the diets caused growth depression. There was no beneficial effect of synthetic vitamin C (T_2), amaranthus (T_4), tiger nut (T_5) and the mixture (T_6) on the final body weight of broiler chickens as they exhibited lower body weight gain when compared to the control.

Feed intake obtained in this study was lower than the values reported by [4]. It also contradicted the report of [17] that combination of vitamins C and E promoted feed intake of broilers reared in thermoneutral or heat stress environment. The feed intakes of broilers fed control and vitamin C diets were significantly higher than those fed other diets. This finding was in accordance with the observation of [3] that broilers fed synthetic vitamin C showed better feed intake. There were no significant differences ($P>0.05$) in feed conversion ratio at 4th and 8th week of the study. Mortality was at the highest among broilers fed control diet (T_1) which agreed with the findings of [3] and [18]. However, the mortality was lower than the findings reported by [19] when Isa Vedette broiler birds were fed *ad libitum* under chronic heat stress. Therefore, it can be inferred from the rate of mortality among the treatments that the anti-stress and antioxidant properties of synthetic vitamin C, baobab pulp and tiger nut reduced the rate of mortality among these birds during the hot-dry season.

Nutrient retention and cost-benefit analysis of broilers fed vitamin C, baobab, amaranthus and tiger nut showed significant differences among treatments (Table 4). Ether extract retention of birds fed test ingredients compared favourably with control diet in this study. Broiler chickens fed vitamin C and amaranthus had significantly ($P<0.05$) better crude protein (CP) retention than those fed other diets. Furthermore, Broilers fed baobab and control diets had similar crude protein retention. However, those fed tiger nut and the mixture of the test ingredients had lowest crude protein retention. Crude protein retention of broilers in this study was generally low. The low retention of crude protein obtained in the present study might be due to heat stress experienced by experimental birds because when feed intake declines during heat stress, availability of important nutrients may have been reduced. This corroborated the findings of [20] who found that the true digestibility of 12 amino acids was generally depressed in two rapeseed- and two soybean meal- diets when fed to broilers subjected to an increased ambient temperature exposure from 21 to 32°C. It may equally be due to the presence of anti-nutritional factors like tannins and saponins which could affect feed intake as well as digestion in birds as reported by [21,22]. Nutrient retentions obtained in the present study were lower than those in the reports of [23,24]. Birds fed vitamin C diet (T_2)

Table 3. Growth performance and mortality of broilers fed vitamin C, baobab, amaranthus and tiger nut (g/bird)

Parameters	T_1	T_2	T_3	T_4	T_5	T_6	SEM	P-value
Day old weight (g)	45.50	45.00	45.00	45.50	45.00	44.50	0.31	0.252
Final weight (g)								
4th week	652.50^{a}	660.00^{a}	627.50^{a}	637.50^{a}	615.00^{a}	572.50^{b}	13.79	0.004
8th week	1750.00^{a}	1500.00^{a}	1650.00^{ab}	1450.00^{b}	1550.00^{b}	1450.00^{b}	63.42	0.020
Daily feed intake (g)								
1-4 weeks	37.65^{a}	38.30^{a}	35.35^{c}	37.09^{ab}	36.05^{bc}	32.90^{d}	0.40	0.0001
5-8 weeks	66.85^{a}	66.65^{a}	64.78^{b}	65.20^{b}	63.55^{c}	62.53^{d}	0.22	0.0001
Daily weight gain (g)								
1-4 weeks	23.30^{a}	23.57^{a}	22.41^{ab}	22.77^{ab}	21.96^{b}	20.45^{c}	0.49	0.004
5-8 weeks	62.50	53.57	58.93	51.79	55.36	51.79	2.55	0.078
Feed conversion								
1-4 weeks	1.61	1.62	1.58	1.63	1.64	1.61	0.04	0.425
5-8 weeks	1.07	1.24	1.10	1.26	1.15	1.21	0.20	0.219
Mortality (%)								
	30.00^{a}	10.00^{b}	10.00^{b}	25.00^{ab}	10.00^{b}	15.00^{ab}	5.00	0.036

Means along the same row with uncommon superscripts are significantly different (P<0.05)

Table 4. Nutrient retention and economic indices of broilers fed vitamin C, baobab, amaranthus and tiger nut

Parameter	T_1	T_2	T_3	T_4	T_5	T_6	SEM	P-value
Dry matter	78.19^{a}	78.34^{a}	77.31^{a}	75.79^{ab}	73.41^{c}	77.06^{a}	0.42	0.0001
Crude protein	48.91^{b}	49.65^{a}	48.74^{b}	49.58^{a}	47.36^{c}	47.3^{c}	0.11	0.0001
Crude fibre	40.00^{e}	52.32^{d}	65.21^{b}	58.00^{c}	62.50^{b}	68.43^{a}	0.95	0.0001
Ash	40.00^{bc}	66.67^{a}	50.04^{abc}	60.00^{ab}	50.00^{abc}	36.36^{c}	6.96	0.052
Ether extract	62.50^{d}	71.43^{ab}	68.75^{bc}	68.75^{bc}	66.67^{c}	74.50^{a}	1.08	0.0001
Total cost (N)	870.00^{ab}	900.80^{a}	868.80^{ab}	881.60^{a}	867.20^{ab}	835.20^{b}	0.08	0.069
Feed cost (N⁄kg)	428.80^{e}	489.60^{d}	392.00^{e}	598.40^{b}	563.20^{c}	652.80^{a}	0.08	0.0001
Total revenue (N)	1454.40^{a}	1204.80^{d}	1355.20^{b}	1155.20^{e}	1254.40^{c}	1155.20^{e}	0.09	0.0001
Profit (N)	584.40^{a}	304.00^{de}	486.20^{b}	273.60^{e}	387.20^{c}	320.00^{d}	0.09	0.0001
Economic Efficiency of growth	0.67^{a}	0.34^{d}	0.56^{b}	0.31^{d}	0.45^{c}	0.38^{c}	0.01	0.0001

Means along the same row with uncommon superscripts are significantly different (P<0.05)

had the best crude protein and ash retentions. This might be due to the anti-stress and antioxidant properties of synthetic vitamin C. Birds fed tiger nut diet T_5 had the least crude protein retention probably because of higher crude fibre content of tiger nut. The lower crude protein retention obtained for birds fed tiger nut in this study might have resulted from nutrient intake restriction precipitated by lower feed intake or nutrient dilution effect of crude fibre. This agreed with the observation of [25] who reported implications of restricted feed intake on the growth rate and body weight performance of broiler breeders. Cost benefit indices of heat-stressed broiler chickens revealed that the control (T_1) produced maximum profit and best economic efficiency of growth. However, more mortality was observed for control broilers than those fed the test ingredients. Furthermore, birds fed baobab yielded (P<0.05) more profit and improved economic efficiency of growth than those fed vitamin C, amaranthus, tiger nut and the mixture of the test ingredients.

4. CONCLUSION

In conclusion, the study revealed that during a hot-dry season, especially in the tropics, baobab pulp was an excellent replacement for industrial vitamin C. This was because birds fed baobab pulp performed better than their counterparts fed amaranthus and tiger nut in terms of final body weight, profit and economic efficiency of growth. Furthermore, their performance was similar to those fed control and vitamin C diets. However, broiler chickens fed control diet had higher mortality than those fed vitamin C and baobab.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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