EFFECT OF SUBSTITUTING MAIZE WITH SORGHUM WASTE ON BLOOD PARAMETERS OF BROILER IN NIGERIA

OBIENYEM, J. N.[1] – EZEBO, R. O.[2*] – OZOH, C. N.[3] – OMUMUABUIKE, J. N.[4] – NWANKWO, C. A.[5]

[1] *Department of Animal Health and Production Technology, Anambra State Polytechnic, Anambra State, Nigeria.*

[2] *Department of Botany, Nnamdi Azikiwe University, Anambra State, Nigeria.*

[3] *Department of Applied Microbiology and Brewery, Nnamdi Azikiwe University, Anambra State, Nigeria.*

[4] *Department of Animal Science, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.*

[5] *Department of Animal Science and Technology, Nnamdi Azikiwe University, Anambra State, Nigeria.*

**Corresponding author*
e-mail: esau_056[at]yahoo.com

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Abstract. This study investigated the effect of substitution of maize with sorghum waste on blood parameters of mixed sex Anak 2000 breed of broiler chickens in the semi-arid zone of Nigeria. Sixty 3 weeks old broiler chicks were randomly assigned to five dietary treatments. Diet 1 contained 0% sorghum waste as control (T1), Diet 2 contained 10% sorghum waste replacing maize (T2), Diet 3 contained 20% sorghum waste replacing maize (T3), Diet 4 contained 30% sorghum waste replacing maize (T4), and Diet 5 contained 40% sorghum waste replacing maize (T5). Each treatment consisted of 12 birds and each treatment was replicated three times in randomized complete block design (RCBD). The blood parameters determined were red blood cells (RBC) count, white blood cells (WBC) count, haemoglobin (Hb) concentration, packed cell volume (PCV), blood protein, blood glucose, blood calcium, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and blood phosphate. For RBC, PVC, Hb, and WBC analysis of variance indicated that the control (T1) had significantly ($p<0.05$) higher values than the other treatment groups. There were no significant ($p>0.05$) difference between treatments for MCV, MCH and MCHC and blood glucose. Birds in T3and T4 had significantly higher ($p<0.05$) blood protein than those in T1, T2 and T5. Also, T3, T4 and T5 treatment groups had significantly higher ($p<0.05$) blood calcium and blood phosphate than T1 and T2. From the results of this study, inclusion of sorghum waste tends to depress RBC, PCV, Hb, and WBC, and has no effect on MCV, MCH and MCHC and improved blood protein, blood phosphate and blood calcium.
Keywords: *substituting, maize, sorghum, waste, blood, broiler*

Introduction

As the population of Nigeria continues to increase in a geometric pattern, food supply particularly, protein supply lags behind in arithmetic pattern. Ladokun and Longe (2004) have stated that one of the ways of increasing protein supply for the Nigerian population is through broiler production. Broilers are poultry birds used mainly for meat, and in recent years occupied a leading role in meeting the animal protein need of people worldwide (Meremikwu and Udedibie, 2007). The high price of conventional poultry feed ingredients in Nigeria has increased the feeding cost to about

80% of the total cost of production (Olomu, 2003; Durunna et al., 1999). This is due to the stiff competition between human and monogastric animals for the already scarce conventional feed resources (Ladokun and Longe, 2004; Abeke et al., 2003). The resultant effects have been low production level, narrow profit margin and collapse of the once prosperous poultry farms. In the present time, the choice of feed is determined to a large extent by price rather than by quality of feed (Ubosi and Sekura, 2000). This development has also contributed to the indiscriminate appearance of new commercial feeds in the market, the quality of such commercial feeds being doubtful because no quality grading system is in place. Chickens have short generation interval and therefore are the choice animal species for achieving sustainable and rapid production of animal protein for human consumption (Alikwe et al., 2005). Unlike other forms of animals (livestock) that have either or both cultural taboos and religious prohibitions attached to them, the chickens have neither restrictions in all parts of Nigeria (Atteh, 2004). Ikeme (1990) also reported that poultry, particularly broilers are fast growing birds, with high feed efficiency, reaching the required market weight of 2 kg within eight to twelve weeks (8-12 weeks) of age.

In a world where malnutrition and starvation stare the entire human race at the face, it is amazing that there exist some agro-industrial by-products lying waste, which could be utilized for increased food production, especially livestock and poultry, to supply protein (Abeke et al., 2003). In cases where agricultural by-products are utilized, they are inappropriately or grossly under-utilized; not withstanding their favourable yield characteristics and relatively lower cost (Fanimo et al., 2007). This study evaluated the effect of substitution of maize with sorghum waste on broilers with respect to blood components and general blood chemistry.

Materials and Methods

Location of study

The study was conducted at the Livestock Teaching and Research Farm of the University of Maiduguri. Maiduguri is situated at latitude 11o51' North, longitude 30o09' East and on an altitude of 364m above sea level in the north-eastern part of Nigeria (Alaku and Moruppa, 1983). Maiduguri falls in the semi-arid zone characterized by a shorter rainy season (3 to 4 months), longer period of dry season (8 to 9 months), hot and dry climate, and has ambient temperatures that can be as high as 40°C and above by the months of April, May and June; and as low as 200C during the months of November, December and January (Ubosi, 1988; Kwari and Ubosi, 1991). The area is therefore, prone to extreme weather conditions and variations (Ugherughe and Ekedolum, 1986).

Experimental stock and management

Sixty, three weeks old Anak – 2000 straight line broilers were used for this study. They were purchased as day old chicks from ECWA rural development, Jos. They were brooded and reared together and food and water were then provided. After three weeks of age, they were transferred into the experimental pens. The birds were randomly assigned to five treatment groups of twelve birds each. The birds were given conventional husbandry practices and were vaccinated accordingly.

Preparation of sorghum waste

Burukutu waste

Sorghum grains are soaked in water for 2 days and covered well to allow for sprouting which will lead to the starch content to be converted to maltose. The sprouted grains are sundried and ground. These ground material serves as yeast for the local alcohol drink preparation. Some unsoaked sorghum flour are also soaked for about 2 days to ensure fermentation and then cooked and allowed to cool by spreading on trays. The ground sprouted grains (yeast) and the cooked materials are then mixed thoroughly in the ratio of 1:3 respectively and allowed for further fermentation which lasts for 2 days. The mixture is then filtered using a sieving cloth. The liquid part is now the local alcoholic drink (Burukutu) and the resulting residue is the sorghum waste. The sorghum waste is wet to pigs but usually sundried for preservation as a livestock feed (ruminants and monogastrics alike). It is this sundried sorghum waste that has been used to substitute the different percentages of maize in a compounded broilers ration used for this study.

The experimental diests (treatments)

Five different diets were formulated using locally procured feedstuffs including yellow maize, sorghum waste, groundnut cake, fish meal, bone meal, wheat bran and salt. The test material; sorghum waste was incorporated into the five experimental diets at 0% (control), 10%, 20%, 30%, and 40% levels replacing the portions of maize as the source of energy for diets 1, 2, 3, 4 and 5 respectively. A vitamin/mineral supplement; “Vitalyte” was given as an anti-stress during the experimental period. Vitalyte is a combination of vitamins, electrolytes and amino acids. The compositions of the 5 experimental diets are presented in *Table 1*.

***Table 1**. Composition of the experimental diests.*

Ingredient (%)	Levels of substitution of maize with sorghum waste (%)				
	1	2	3	4	5
Maize	56.00	50.40	44.80	39.20	33.60
Sorghum waste	0.00	5.60	11.20	16.80	22.40
Groundnut cake	23.00	24.00	25.00	26.00	27.00
Fish meal	8.00	7.00	6.00	5.00	4.00
Bone meal	2.50	2.50	2.50	2.50	2.50
Wheat bran	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Experimental procedure

The sixty Anak – 2000 broilers were individually weighed and randomly assigned to five different treatments. Twelve birds each were assigned to each treatment and each treatment was replicated three times making 4 birds per replicate. The birds were fed the experimental diets and water *ad libitum*.

Data collection

At 9 weeks of age, blood samples were collected and used to determine the status of the following blood parameters; white blood cells (WBC), red blood cells (RBC), haemoglobin (Hb), Packed Cell Volume (PCV), blood albumin, blood glucose, blood protein, blood calcium and blood phosphorus. A total of twenty samples were collected from the whole treatment groups for analysis. Four birds from each treatment were bled. The blood samples were collected from the brachial vein of the birds. Blood samples were gently transferred to the bijou bottles, each contained ethylene diamine tetra acetic acid (EDTA) which served as an anticoagulant. The EDTA bottle with blood samples were gently filtered to ensure proper mixing of the blood with EDTA to prevent clotting. The blood samples were analyzed at the University of Maiduguri Teaching Hospital Haematological Unit and the Veterinary Teaching Hospital.

Blood analytical procedures

Packed Cell Volume (PCV)

The Packed Cell Volume was determined by a micro-haematocrit method. Blood in the EDTA bottle was gently and thoroughly mixed by inverting the tube several times. The blood was then gently drawn into the capillary micro-haematocrit tubes until the tubes were about two- third filled. Vigorous agitation was avoided during the mixing to avoid damage to the cells. The capillary tubes were sealed with plastacine or flame from Bunsen burner. The sealed capillary tubes were placed with the closed and outwards in a micro-haematocrit centrifuge and spun for 5 minutes at 12000 revolutions per minute (rpm). The capillary tubes from the centrifuge were then removed and the percent haematocrit was then read using the micro-haematocrit reader.

Haemoglobin (Hb) concentration

Haemoglobin (Hb) was determined using the cyan methaemoglobin method. The blood samples were properly mixed by inverting the tubes with blood about 20 times. Using 0.02ml (20mm^3) Hb pipette, 0.02ml of blood was sucked, wiping the tip of the pipette. The samples were then washed into 5ml Drabkin’s solution (1/25L dilution) and mixed well and allowed to stand for 10 minutes before analyzing. With an already warmed colourimeter set at 540 nanometer (wavelength) and using a tube of Drabkin’s solution as a blank, the standard solution of cyanmethaemoglobin was read and calculated as follows:

Hb Conc. (g/dl) = reading of the test sample × conc. of standard × dilution/reading of standard

Red blood cell (RBC) count

The preparation of red blood cell dilution and counting were as follows: 4ml of RBC diluting fluid was put into a bijou bottle and mixed with the blood samples by inverting approximately 20 times. Using 20ml pipette with disposable tip, the blood was drawn into the tip and excess blood wiped off from outside of the tip with cotton. The content of the pipette was expelled into the bottle containing the 4ml diluting fluid. The residue in the pipette was then washed out by repeatedly drawing up some of the fluids and returning it into the bottle. By inversion, the bottle contents were mixed and the final dilution of blood contained in the bottle was 1:200 (normal). The RBC counts were determined by a counting chamber method or using a coulter blood counter.

White blood cell (WBC) count

The white blood cell dilution was prepared by placing 0.95ml of WBC diluting fluid into a bijou bottle and the blood samples mixed with it by inverting for about 20 minutes avoiding agitation. Then by using 50ml pipette, blood was drawn up, while excess blood was wiped off the outside of the tip. The contents of the pipette was expelled into the bottle 3-4 times and dilution of the blood contained in the bottle was done at the ratio 1:20. This method is similar to that of red blood cell dilution except for the diluting fluid and ratio. The counting technique is also exactly as for red blood cell counting except that the squares counted on the chamber are the four corner 1mm squares.

Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC)

The MCV, MCH, MCHC were all determined by calculation from the RBC count, Hb concentration and PCV values. Swenson (1970) gave the standard formula for all these parameters as follows:

$$\text{MCV, Fentolitres (fl)} = \text{PCV\%} \times 10/\text{No of RBC} \times 10^6 \text{mm}^3 \quad \text{Eq. (1)}$$
$$\text{MCH, Picograms (pg)} = \text{Hb/dl} \times 10/\text{No of RBC} \times 10^6 \text{mm}^3 \quad \text{Eq. (2)}$$
$$\text{MCHC (\%)} = \text{Hb (g/dl)} \times 100/\text{PCV (\%)} \quad \text{Eq. (3)}$$

Blood total protein

The determination of plasma protein was done using colourimetric methods using biuret reaction. In this biuret method, measured quantity of the biuret reagent was mixed with the test solution properly and incubated at 370C for 10 minutes. By setting the spectrophotometer at 540nm, the percentage transmissions were read off the screen.

Blood glucose

This was determined by the enzymatic method using the glucose oxidase that is manufactured by R and OX laboratories Limited, United Kingdom.

Blood phosphorus and calcium

These were determined by colourimetric method. Inorganic phosphate in serum reacts with Molybdic acid to form a phosphomolybdic acid complex, which is reduced by Ammonium iron (ii) sulphate to molybdenum blue, which is measured at 690nm. High turbidity was avoided during use by sampling serum.

Chemical analysis

The five different experimental diets were analyzed to determine the proximate composition according to the methods outlined by the Association of Official Analytical Chemists (AOAC, 1990).

Dry matter determination

About 2 g of the experimental diet was weighed into a Petri dish, using an electronic balance and fed into an oven. The sample was oven-dried at a temperature of 105oC for 24 hours to attain a constant weight. The difference between the original and final weight, which is the percent moisture (M) was calculated as:

% MC = [(W1 – W2)/W] x 100 Eq. (4)

Where W1 = weight of sample + Petri dish before drying; W2 = weight of sample + Petri dish after drying; W = weight of sample; and % MC = percentage moisture. The percent dry matter was then calculated by subtracting the %moisture from 100 as follows:

%DM=100 – %moisture Eq. (5)

Crude protein (CP)

The crude protein was determined by Kjedahl method (AOAC, 1990). This involves three stages as follows:

Digestion

About 2 g of the prepared sample was placed in a digestion tube. Two digestion tablets and 20 ml of concentrated sulphuric acid were added. The tube was then placed in a digestion block and covered with the exhaustion cap. After being completely digested the sample was allowed to cool at room temperature and diluted with distilled water to a volume of 100 ml.

Distillation

About 50 ml of the digested sample was measured out and placed in a distillation flask along with 50 ml of NaOH which reacted with ammonium sulphate (resulting from protein + H_2SO_4 to give NH_4OH + Na_2SO_4). The steam from water that heated in the machine passed through the digested sample + NaOH to "carry over" the NH4OH that was condensed into a receiver flask containing boric acid + bromo-cresol green and methyl red indicators. The NH_4OH in boric acid changed the initial reddish colour of boric acid to green, indicating the presence of a base (NH_3).

Titration

The green distillate was then titrated with 0.1 normal HCL. This then changed it to its original reddish colour. The crude protein (CP) was then calculated as follows:

CP = {[(A – B) x N x F x 14.007] / weight (g) of sample used} x 100 Eq. (6)

Where A = Ml of acid used in titrating the sample; B = Ml of base used in titrating the blank; N = Normality of the acid used in titration; and F = Conversion factor (6.25).

Crude fibre (CF)

About 1 g of each of the feed samples was digested with 100 ml of the digestion reagent (20 g trichloroacetic acid, 500 ml glacial acetic acid and 50 ml NHO_3 and 450 ml of distilled water). The flask containing the sample and reagent was boiled and refluxed for 40 minutes. The digested sample was then removed and allowed to cool to room temperature and then filtered through an ash-less filter paper of known weight. The filtered sample was washed six times with hot distilled water to remove carbohydrate and protein, then once with petroleum spirit to remove fat. The paper was then placed in a oven at 80°C overnight to remove all the moisture and then weighed. The residue (paper + fibre) after drying was ashed in a muffle furnace at 550°C for 3 hours and the ash, so formed, weighed. Percent crude fibre (CF) was then calculated according to Soest and Wine (1967) as follows:

% CF = (Oven dried weight – weight of ash + paper) X 100 Eq. (7)

Ether extract (EE)

About 2 g of each sample was placed in a thimble (filter paper – like container) and the mouth closed with cotton wool. The thimble was then placed into an extraction chamber of a Soxhlet system. The chamber was fixed to an extraction flask (round bottom flask of 250ml capacity) in which 200 ml of petroleum ether was fed. The two units were fixed to a heating mantle and a condenser placed on the top of the unit. The heating mantle was turned on to a temperature of 60oC. After about 5 hours the ether coming down was received in a beaker leaving the flask with only the extracted fat. The flask was then oven-dried at 100oC for one hour, cooled in a desiccator and weighed. The ether extract was then calculated as follows:

EE = [(Weight of oil flask after extraction – Weight of empty oil flask)/Weight of dried material taken] X 100

Eq. (8)

Ash

About 1 g of each of the samples was fed into a crucible of known weight and then incinerated at 600^{o}C for 3 hours in a furnace. The resultant ash was cooled in desiccators and then weighed. Percent ash was calculated as follows:

% Ash = [(Weight of ash)/Weight of dried sample] X 100

Nitrogen-free extract (NFE)

This was calculated by difference. The summation of CP, CF, EE and Ash was subtracted from 100 as follows:

%NFE = 100 – %(CP + CF + EE + Ash) Eq. (9)

Metabolizable energy (ME)

Metabolizable energy per kg feed was calculated according to Pauzenga (1985) as follows:

ME (kcal/kg) = 37 (% CP) + 81 (% EE) + 35.5 (% NFE) Eq. (10)

Where ME is metabolizable Energy; CP is crude protein; EE is ether extract and NFE is nitrogen- free extract.

Statistical analysis

All the data collected on blood parameters were subjected to Analysis of Variance (ANOVA) using a randomized complete design. Significant differences between different treatment means were separated using the Least Significant Difference (LSD).

Results and Discussion

Proximate composition of experimenta diets

The result of the proximate analysis of the test diets are presented in *Table 2*. The crude protein levels in all test diets ranges between 10.50 to 21.35%. These levels in T1, T2 and T3 are below the range recommended for broiler finishers (19-21%) by Olomu (1979). The crude protein and the crude fibre increased with increasing sorghum waste levels in the diets. The Nitrogen free extract decreased from T1 to T5 while the ether extracts increased from treatment T1 up to T3 and thereafter declined. The calcium levels reduced from treatments T1 to T3 and then increased from 4 to 5. The highest value was recorded in treatment 1 and the lowest value in treatment 3. The calcium levels in all the diets except for T1 (control) are below the 0.7 to 1.0% recommended for broiler finishers (Olomu, 1979). Similarly, the phosphorus levels in treatments 1 and 2 are above the 0.5% level recommended for broiler finishers (Olomu, 1979). The calculated metabolizable energy values in the diets ranged between 2608.24 to 3205.76 kcal/kg. The levels are within the recommended range of 2800 to 3,000 kcal/kg for broiler finishers (Olomu, 1979). The test ingredient has 17.05% crude protein. This crude protein value is above the 15% CP value obtained by Igwebuike et al. (1995). The nutrients variations in the experimental diets are attributed to the varying inclusion levels of sorghum waste.

***Table 2**. Proximate composition of the experimental diests and sorghum waste.*

Nutrient (%)	Levels of substitution of maize with sorghum waste (%)					
	1	2	3	4	5	SW
Dry matter (DM)	92.50	92.75	92.90	93.00	94.00	96.20
Crude protein (CP)	14.20	10.50	14.25	21.35	21.30	17.05
Moisture content (MC)	7.50	7.25	7.10	7.00	6.00	3.80
Crude fibre (CF)	2.00	3.00	7.00	8.00	15.50	15.00
Ether extract (EE)	8.00	8.30	7.50	10.50	15.00	4.00
Nitrogen-free extract (NFE)	55.20	55.25	45.45	36.45	25.00	47.99
Ash	13.10	15.70	18.70	16.70	17.20	8.00
Calcium	1.30	0.60	0.25	0.50	0.65	0.51
Phosphorus	1.20	0.74	0.43	0.43	0.40	5.69
Metabolizable energy (Kcal/kg)	3205.76	3061.20	2608.24	2833.36	2771.76	2588.60

Blood parameters

Data for the blood parameters measured are shown in *Table 3*. They include the packed cell volume (PVC), haemoglobin (Hb) concentration, red blood cells (RBC), white blood cells (WBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), blood glucose, blood protein, inorganic phosphorus and calcium.

***Table 3**.Blood parameyers affected by feeding different level of sorghum waste in broiler chickens.*

Parameters	Levels of substitution of maize with sorghum waste (%)				
	1	2	3	4	5
RBC ($\times 10^6$/mm^3)	5.54+0.19^a	4.41+0.33^b	3.79+0.13^b	4.53+0.04^b	3.82+0.39^b

PCV (%)	$28.50+0.50^{a}$	$25.00+1.00^{b}$	$21.50+0.50^{d}$	$24.50+0.50^{bc}$	$22.50+0.50^{cd}$
Hb (g/dl)	$8.75+0.15^{a}$	$8.05+0.65^{ab}$	$6.75+0.25^{b}$	$7.80+0.50^{ab}$	$7.00+0.20^{b}$
WBC ($\times10^{3}$/mm^{3})	$20.69+0.94^{a}$	$17.13+0.38^{ab}$	$14.00+0.25^{b}$	$16.75+1.76^{b}$	$14.69+1.06^{b}$
MCV (fls)	$51.48+0.87^{a}$	$56.90+1.93^{a}$	$56.75+0.63^{a}$	$54.16+1.53^{a}$	$59.39+4.77^{a}$
MCH (pg)	$15.81+0.28^{a}$	$18.27+0.13^{a}$	$17.81+0.05^{a}$	$17.25+1.24^{a}$	$18.47+1.37^{a}$
MCHC (%)	$30.70+0.01^{a}$	$32.15+1.32^{a}$	$31.39+0.44^{a}$	$31.81+1.39^{a}$	$31.11+0.20^{a}$
Blood glucose (mg/dl)	$154.80+0.10^{a}$	$153.90+1.56^{a}$	$143.10+0.65^{a}$	$153.00+0.50^{a}$	$165.60+0.00^{a}$
Blood protein (g/dl)	$2.65+1.50^{b}$	$2.70+1.00^{b}$	$3.25+0.50^{a}$	$3.25+0.50^{a}$	$2.85+1.50^{b}$
Inorgaic PO_4^{2-}	$32.30+0.40^{ab}$	$19.48+0.75^{b}$	$33.25+0.00^{a}$	$28.03+0.15^{ab}$	$34.68+0.15^{a}$
Calcium (mg/dl)	$7.40+0.15^{b}$	$7.60+0.10^{b}$	$9.60+0.10^{a}$	$8.60+0.15^{ab}$	$10.20+0.15^{a}$

Notes: PCV=Packed cell volume; Hb=Haemoglobin; RBC=Red blood cells; WBC=White blood cell; MCV=Mean corpuscular volume; MCH=Mean corpuscular haemoglobin; MCHC=Mean corpuscular haemoglobin concentration; a,b,c=In the same row bearing the same superscripts are not significantly (p>0.05) different.

RBC, WBC, Hb and PCV

The mean RBC count for the five treatment groups are 5.54 × 106, 4.41 × 106, 3.79 × 106, 4.53 × 106 and 3.82 × 106 for treatments 1, 2, 3, 4 and 5 respectively. The birds in the control treatment (T1) have a significantly (p<0.05) higher RBC count than those in T2, T3, T4 and T5. There are however, no significant (p>0.05) differences between treatments 2, 3, 4 and 5 for RBC count. The RBC count decreased with increasing levels of sorghum waste. The RBC values observed in this study were all above the normal range (2.0-3.80 × 106/mm^3) reported by Bell and Freeman (1971) despite the high temperatures prevailing during the study period which has depressive effect on RBC (Huston et al., 1962). The Hb values for the five treatments were 8.75, 8.05, 6.75, 7.80 and 7.00 g/dl respectively for the control and treatments 2, 3, 4 and 5. There were no significant (p>0.05) differences between the control T1, T2 and T4 groups. Similarly, there were no significant (p>0.05) differences between treatments 2, 3, 4 and 5. The T1 group however, have significant (p<0.05) Hb values than T3 and T5. The Hb values decreased from the control up to treatment 3 and thereafter increased again. The lowest value of Hb was therefore, observed in T3 group. The Hb values for all the treatment groups fall within the normal range (6.5 – 9g/100ml) for chickens reported by Swenson (1970), which is also consistent with the report of Siegmund (1973).

The mean WBC values for the five different treatments were 20.69, 17.13, 14.00, 16.75 and 14.69 × 103/mm3 respectively. There were no significant (p>0.05) differences between T3, T4 and T5. However, T1 and T2 groups have significantly (p<0.05) higher WBC count than T3, T4 and T5. The values obtained are consistent with the normal range (5-25 × 103/mm3) for chickens given by Siegmund (1973). The WBC count decreased with increasing levels of sorghum waste. This could be attributed to the high fibre levels in the sorghum waste treated diets. The PCV values were 28.50, 25.00, 21.50, 24.50 and 22.50% for treatments 1, 2, 3, 4 and 5 respectively. There were significant (p<0.05) difference between treatments. Birds in T1 have significantly (p<0.05) higher PCV than all the other treatments. Also, T2 group have significantly (p<0.05) higher PCV than T3 and T5. There were however, no significant (p>0.05) differences between T2 and T4, T3 and T5. All the values fall within the range (20-40%) for chickens reported by Newell and Shaffner (1950) as well as Hunsaker (1969). The PCV values followed the pattern of RBC counts which is normal as it is the RBC that settles after centrifuging to give the PCV measurement.

MCV, MCH and MCHC

The values for MCV, MCH and MCHC are shown in *Table 2* previously. There were no significant ($p>0.05$) difference for MCV, MCH and MCHC for all the five treatments. Swenson (1970) reported that MCV, MCH and MCHC are indices of RBC and are used to measure the size and Hb content of erythrocytes which make them vital in diagnosing various anaemic conditions in animals. The MCV values in this study are lower than the 127 fentolitres normal value for birds and this indicates that the birds are somehow anaemic which could be due to the general high temperature during the study period. The values however, increased with sorghum waste inclusion in the diets which might be attributed to the low energy levels in the sorghum treated diets. The low energy will tend to reduce the internal heat generation in the body of the birds.

Blood chemistry

The blood chemical components determined are total protein (mg/dl), glucose (mg/dl), inorganic phosphate (mg/dl) and calcium (mg/dl). The blood protein values for the five treatments were 2.65, 2.70, 3.25, 3.25 and 2.85g/dl for T1 (control), T2, T3, T4 and T5 treatments respectively (*Table 3*). Birds in T1, T2 and T5 have significantly ($p<0.05$) lower blood protein than T3 and T4. The blood protein increased with increasing sorghum waste up to T4 and thereafter declined. The blood protein values for all treatment groups were lower than the average value for laying hens (5.4g/dl) and (3.6g/dl) for non-laying birds reported by Swenson (1970). They were also lower than the 4g/dl reported by Bell and Freeman (1971) which he stated as the lower limit for blood protein content of non-laying fowls. Deaton et al. (1969) as well as Squibb and Reed (1969) have reported that high ambient temperatures decrease blood protein in domestic fowls. This could be the reason for the lower values in all the treatments compared to the normal values.

Blood glucose values were 154.80, 153.90, 143.10, 153.00 and 165.60mg/dl for the control and T2, T3, T4 and T5 respectively. There were no significant ($p>0.05$) differences between all the treatments. All values obtained were below the normal glucose level (225.7mg/dl) reported by Balasch et al. (1973) and 192-217mg/dl range observed by Vo and Boone (1975) for laying hens. The blood glucose values decreases with increasing sorghum levels up to 20% and then rose again. The trend almost followed that of RBC count contrary to the report of Bell and Freeman (1971) which stated that blood glucose in the blood of fowls is inversely proportional to the volume percent of the RBC. The blood calcium values were 7.40, 7.60, 9.60, 8.60 and 10.20mg/dl for control and T2, T3, T4 and T5 treatments respectively. The blood calcium levels in all the treatments were above the 4.5-6.0mg/dl reported by Swenson (1970) for non-laying hens. Although, the values for T3, T4 and T5 fall within the 8.5-19.5mg/dl range reported by Swenson (1970) for laying hens. The blood calcium increased with increasing levels of sorghum waste. This agrees with the reports of Pollin and Sturkie (1954) that blood calcium levels in fowls increased with calcium intake since calcium in the diets increased with increasing sorghum waste incorporation. Similar reports have been given by Mueller (1959).

Blood phosphate levels for the control, T2, T3, T4 and T5 treatments were 32.30, 19.48, 33.25, 28.03 and 34.68 mg/dl respectively. Swenson (1970) gave the normal blood phosphate levels as 4.0 to 6.4meq/L serum and 2.6-5.2meq/L serum for laying and non-laying chickens respectively. In general, the blood parameters (RBC count, PCV, Hb concentration and WBC) all decreased from the control up to treatment 5, the highest sorghum incorporation level. This indicates that sorghum inclusion in diets of broilers has a depressive effect on those blood parameters.

Conclusion

From the results of this study, it shows that sorghum waste does not seem to have adverse effects on the RBC, PVC, Hb and WBC. However, the study shows that blood glucose, blood protein, phosphate and calcium increased with increasing levels of sorghum waste in the diets. Therefore, sorghum waste can be recommended to be incorporated in broiler diets up to 40% since the sorghum waste is less expensive and that it is not competed for by humans and livestock. Sorghum waste is a good source of energy and it is also rich in proteins, minerals (ash) and some essential amino acids and vitamins (Vitamin B). It can conveniently be used in broiler diets. However, further studies are required to relate the optimum level of sorghum waste in broiler diets. The study should be conducted during other periods of the year and higher levels as well as using some additives which would enhance fibre utilisation should be evaluated.

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Conflict of interest

The authors confirm that there is no conflict of interest involved with any parties in this research study.

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