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*Full Length Research Paper*

# Effects of graded levels of cottonseed cake on performance, haematological and carcass characteristics of broilers fed from day old to 8 weeks of age

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**Cottonseed cake (CSC) has been used as a cheaper alternative to soyabean cake (SBC) in livestock feeding and a source of dietary protein. There is, however, paucity of information on its nutritive value in chickens. This study evaluated the performance, haematological and carcass characteristics of chickens in which CSC replaced SBC in a nutritional experiment. One hundred and eighty day old chicks (DOC) were fed with 5 different diets, such that 0% (control), 25, 50, 75 and 100% of CSC replaced SBC from day old to 8 weeks of age. Average weekly gains (AWG), feed conversion ratio (FCR) and dressed weight (DWT) were monitored. Blood samples were collected and analyzed for differential white blood cell count (lymphocyte) and haemoglobin (Hb). Data were analysed using descriptive statistics and analysis of variance. Values of AWG and DWT ranged from 0.1 to 0.4 kg and 1.1 to 1.8 kg, respectively, with 100% CSC and control having the least and the highest values among the treatments. FCR ranged from 1.6 to 4.9. Values of lymphocyte and Hb ranged from 35.2 to 54.0% and 8.5 to 11.1 g/dl, respectively. Birds on 75% CSC based diets had blood profile comparable to the control than those of other diets. CSC can replace up to 75% SBC without adverse effects on performance, haematological values and carcass quality of the birds. This reveals CSC as a potent source of protein for meeting the crude protein requirements of chickens.**

**Key words**: Chicken, cottonseed cake, performance and haematology.



## INTRODUCTION

Cottonseed cake (CSC) is a by-product of the textile industry which is in abundance yet its utilization as a feed ingredient for poultry is limited due to its gossypol content, a poly-phenolic pigment implicated in protein digestion which reduces performance and increases mortality in chickens (Couch et al., 1955; Smith and Clawson, 1970).

However, several authors have shown that chick performance is not retarded when dietary level of free gossypol is lower than 250 mg/kg of feed (Heywang and Kemmerer, 1966; Hermes et al., 1983). Although the addition of ferrous sulphate has reduced the adverse effects of gossypol, it is not widely accepted by the poultry industry (Henry et al., 2001).

Other investigators have shown that several factors such as fibre content, protein quality (Phelps, 1966) age, strains of chickens (Clawson and Smith, 1966) and dietary lysine (Martin, 1990) have a direct bearing on the performance of birds. The objective of this research therefore was to determine the effect of CSC on the performance, haematology and carcass characteristics of broilers fed from start to finish with graded levels of CSC based diets.

## MATERIALS AND METHODS

Five isonitrogenous and isocaloric diets were formulated such that CSC replaced SBC in the following order 0, 25, 50, 75 and 100% in a maize based diet. The experimental starter diets containing 2980 kcal/kg ME and 23% crude protein was fed to the chicks for the

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**Table 1.** Composition of experimental finisher diets (kg).

| Ingredient | Diet | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Maize | 56.24 | 50.50 | 49.60 | 48.58 | 47.45 |
| Soyabean cake | 21.70 | 16.20 | 10.85 | 5.42 | 0.00 |
| Cottonseed cake | 0.00 | 6.50 | 13.05 | 19.50 | 26.05 |
| Wheat bran | 13.06 | 17.80 | 17.00 | 17.00 | 17.00 |
| Blood meal | 2.50 | 2.50 | 3.00 | 3.00 | 3.00 |
| Fish meal | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Bone meal | 3.00 | 3.00 | 3.00 | 3.00 | 3.00 |
| Oyster shell | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| *Premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Salt | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Cal. CP (%) | 20.40 | 20.49 | 20.68 | 20.55 | 20.51 |
| Cal. ME(kcal/kg) | 2893.0 | 2890.0 | 2892.0 | 2896.0 | 2889.0 |

*Premix supplied per kg of diet: Vit A, 10,000 IU; Vit D, 2,800 IU; Vit E, 35,000 IU; Vit K, 1,900 mg; Vit $B_{12}$ 19 mg; Riboflavin, 7,000 mg; Pyridoxine, 3,800 mg; Thiamine, 2,200 mg; D-Pantothenic acid, 11,000 mg; Nicotinic acid, 45,000 mg; Folic acid, 1,400 mg; Biotin, 113 mg; Cu, 8,000 mg; Mn, 64,000 mg; Zn, 40,000 mg Fe, 32,000 mg; Se, 160 mg; Iodine, 800 mg; Cobalt, 400 mg; Choline, 475,000 mg; Methionine, 50,000 mg; BHT, 5,000 mg; Spiramycin, 5,000 mg.

**Table 2.** Chemical composition of experimental finisher diets.

| Composition (%) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Dry Matter | 95.56 | 94.25 | 93.85 | 92.75 | 94.46 |
| Crude Protein | 19.89 | 19.42 | 19.68 | 19.72 | 19.57 |
| Crude Fibre | 3.02 | 3.56 | 3.75 | 3.98 | 4.76 |
| Ether Extract | 6.25 | 6.82 | 7.10 | 6.33 | 6.59 |
| Ash | 8.85 | 9.42 | 8.61 | 9.65 | 10.20 |
| NFE | 59.55 | 55.03 | 54.71 | 53.07 | 53.34 |

first 4 weeks of life. The experimental finisher diet containing 2800 kcal ME/kg and 20% crude protein were fed for the last four weeks of life as presented in Table 1 while, the gross composition of the experimental finisher diet is shown in Table 2.

A total of 180 day old mixed sexes Anak broiler chicks were obtained from Avian Hatchery in Ibadan for this study. The chicks were randomly assigned to five dietary treatment groups of 12 birds replicated thrice on the basis of similar average weights in a completely randomized design. After the arrival of the birds, the chicks were removed from their box weighed and divided into fifteen groups of 12 birds each. Each group was randomly allotted to one of the replicates of the dietary treatments. Feed and water were provided *ad libitum*. Other routine management procedures were strictly followed.

Proximate analysis was carried out according to the procedures described by A.O.A.C (1995) for both the test ingredient, cottonseed cake (CSC) and the compounded diets. Free gossypol content of CSC was determined according to the procedure described by the AOCS (1979) and total gossypol was measured using the HPLC method of Hron et al. (1999).

At the 4$^{th}$ and 8$^{th}$ weeks, 2 birds per replicate were randomly selected and bled by the jugular vein from which blood was drained and collected into two carefully labelled specimen bottles for haematological and serum metabolite studies. Feed intake and body weight gain were measured weekly. Two birds per replicate were randomly selected, starved overnight, slaughtered and fully bled for carcass analysis.

### Statistical analysis

Analysis of variance of the data collected was carried out using SAS methods of 1999 at 5% level of probability to assess significant differences. Treatment means were separated using Duncan's multiple range test (Duncan, 1980).

## RESULTS AND DISCUSSION

### Proximate composition

Table 2 shows the chemical composition of experimental finisher diets. The proximate composition of experimental finisher diets did not show any significant differences bet-

**Table 3.** Weekly feed intake (g) of finisher birds fed cotton-seed cake - based diets from day old to 8 weeks of age.

| Treatment | Weeks | | | |
|---|---|---|---|---|
| | 5 | 6 | 7 | 8 |
| 1 | 819.44 | 716.39 | 898.61[b] | 1027.67 |
| 2 | 833.57 | 838.61 | 869.44[b] | 1027.67 |
| 3 | 833.33 | 727.67 | 970.55[a] | 962.50 |
| 4 | 838.32 | 772.22 | 900.10[b] | 966.67 |
| 5 | 833.72 | 766.67 | 902.77[b] | 994.43 |
| SEM | 16.87 | 23.08 | 12.13 | 21.25 |

**ab**: Means in the same column with different superscripts are significantly different (P < 0.05).

**Table 4.** Average weight gain (g) of broiler finishers fed CSC based diets.

| Treatment | Weeks | | | |
|---|---|---|---|---|
| | 5 | 6 | 7 | 8 |
| 1 | 464.00[a] | 220.00 [a] | 320.00 | 350.00[a] |
| 2 | 403.00[b] | 170.00[b] | 380.00 | 310.00[ab] |
| 3 | 369.00[c] | 180.00[b] | 360.00 | 240.00[bc] |
| 4 | 466.00[a] | 160.00[b] | 350.00 | 270.00[ab] |
| 5 | 366.00[c] | 160.00[b] | 350.00 | 200.00[c] |
| **SEM** | 17.40 | 20.00 | 20.00 | 30.00 |

**abc**: Means in the same column with different superscripts are significantly different (P < 0.05).

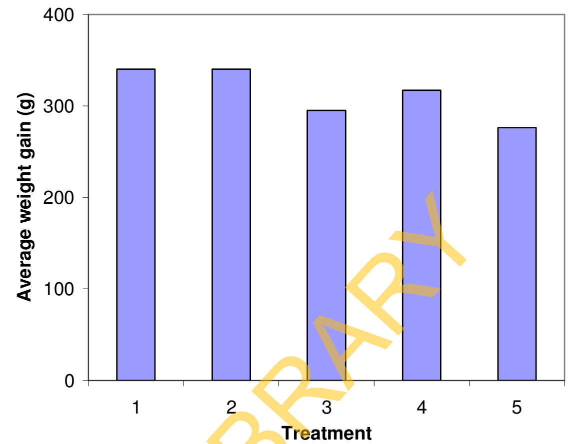


**Figure 1.** Average weight gain (g) of broiler finishers fed CSC- based diets.

ween the five treatments but slight variations in numerical values were obtained. The residual gossypol in the test ingredient as determined by the HPLC method described by Hron et al. (1999) was 570 g/ton, which did not warrant the addition of ferrous sulphate as recommended by Husby and Kroening (1971).

Waldroup (1981) reviewed the literature and concluded that free gossypol concentrations up to 100 ppm were acceptable without iron supplementation and up to 400 ppm gossypol could be fed if iron was supplemental in a ratio of 1 to 2 ppm for each part per million of free gossypol.

## Feed intake

The weekly feed intake expectedly increased with increase in age as shown in Table 3. Significant differences (P < 0.05) were observed only in week 7. Generally, broilers on CSC-based diets did not show any particular trend in their pattern of consumption, though significant differences among treatment means were obtained particularly in the seventh week of feeding trial. The expectation was a step wise increase in feed consumption as the level of CSC increased in the diet, because of increasing fibre level which is known to dilute the energy level of the feed. The explanation for this could be that firstly, the energy level of diets with increasing CSC levels was not significantly affected as the other ingredients adequately made up for the energy need of the animal as the diets were calculated to be isocaloric and isonitrogenous. Secondly the fibre level as determined by chemical analysis did not exceed the recommended level of 5% of the total amount of diets (NRC, 1994). It also gave a picture that the diets were all balanced as to meet the nutrient requirements of the birds for maintenance, growth and tissue development. This work is consistent with the work of Apata and Ologhobo (1990), Emiola et al. (2003) and Akanji (2002) who reported improved utilization of protein of oil seed cakes due to good processing techniques which prevented the formation of protein-iron complexes that may inhibit the digestion of protein.

## Body weight gain

Table 4 shows the values obtained for the average weekly weight gain. Significant differences (P < 0.05) in weight gain were observed in all the weeks of the feeding trial except week 7. During week 7 however, the lowest weight gain was observed for treatment 1 (320 g) which did not differ significantly from the others. The mean weight gain is shown in Figure 1 which did not follow a particular trend. Age significantly affects utilization of nutrients. Higher digestibilities and retentions are the hall mark at early stage of life when birds are actively building up tissues, but that was not the case at the finisher phase. It has been demonstrated that improved performance at the finisher level following early nutrient digestion problem due to the complication of anti-nutrients may or may not produce comparable performance as those reared under normal condition (Plavik et al., 1986; Cable and

**Table 5.** Weekly FCR of broiler finishers fed CSC based diets.

| Treatment | Weeks | | | |
|---|---|---|---|---|
| | 5 | 6 | 7 | 8 |
| 1 | 1.77[b] | 3.25[c] | 2.81[a] | 2.93[d] |
| 2 | 2.07[a] | 4.94[a] | 2.29[c] | 3.31[cd] |
| 3 | 2.26[a] | 4.04[b] | 2.70[a] | 4.01[b] |
| 4 | 1.80[b] | 4.83[a] | 2.57[b] | 3.58[c] |
| 5 | 2.28[a] | 4.79[a] | 2.58[b] | 4.90[a] |
| SEM | 0.17 | 0.20 | 0.08 | 0.14 |

**abc**: Means in the same column with different superscripts are significantly different (P < 0.05).

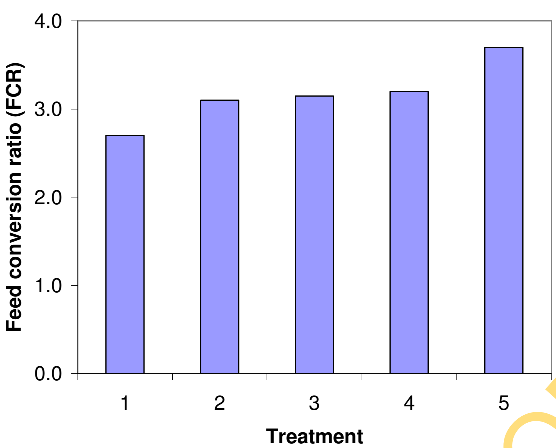


**Figure 2.** Feed Conversion Ratio of broiler finishers fed CSC-based diets.

Waldroup, 1990). In essence, optimal body weight gain in broiler finishers is very much dependent on how well the starters took off.

Total replacement of SBC with CSC protein significantly lowered body weight as compared with the control. This finding is in agreement with the work of Jonston and Watts (1964); Jones and Smith (1977) and Bamgbose (1996) who reported that increasing the level of CSC in the finisher diets resulted in significant depression in the performances of broilers in terms of daily feed intake, daily weight gain and final live weights. CSC replacement for 75% of SBC protein in this work did not differ from the control. This is in agreement with the report of NAPRI (1984) that feeding CSC up to 50% as replacement for SBC in broiler diet had no significant effect on performance of broiler chicken. It also agrees with the report of Ryan et al. (1986) who stated that the inclusion of up to 30% CSC in broiler diet did not significantly depressed feed intake and weight gain of birds. The highest inclusion level of CSC in this work was 32% of the diets.

**Table 6.** PER of broiler finishers fed CSC based diets.

| Treatment | Weeks | | | |
|---|---|---|---|---|
| | 5 | 6 | 7 | 8 |
| 1 | 2.85[a] | 1.55[a] | 1.79[c] | 1.72[a] |
| 2 | 2.49[b] | 1.04[c] | 2.25[a] | 1.55[b] |
| 3 | 2.25[c] | 1.26[b] | 1.88[c] | 1.26[c] |
| 4 | 2.82[a] | 1.05[c] | 1.97[b] | 1.41[b] |
| 5 | 2.25[c] | 1.06[c] | 1.98[b] | 1.03[d] |
| SEM | 0.33 | 0.25 | 0.42 | 0.52 |

**abc**: Means in the same column with different superscripts are significantly different (P < 0.05).

## Feed conversion ratio (FCR)

Table 5 shows the value of the FCR of the finisher diets. FCR values obtained did not show any particular trend though significant differences (P < 0.05) were seen between the different dietary treatments. The average FCR is shown in Figure 2, values increased gradually from treatment 1 to 4 but sharply increased from treatment 4 to 5. Feed conversion ratio is the amount of flesh gained per quantity of feed consumed which adequately reflects the quality of the feed and the ability of the animal to digest it. On the average, feed was converted more efficiently by birds on treatment 1 than other treatments as indicated by the FCR values obtained (2.69). This is in agreement with the report of Oluyemi and Roberts (1979), Babatunde et al. (1976), Olomu and Offiong (1980) of a better FCR as the quality of dietary protein improved. CSC in the diets was probably not as well utilized for body growth as SBC which was the major source of dietary protein in treatment 1 (control). Reid et al. (1987) reported the poor utilization of the protein of CSC due in part to amino acid imbalance associated with unsupplemented CSC diets. Atuahene et al. (1986) also reported that increasing dietary inclusion of glanded CSC in broiler diet resulted in poor carcass yield especially when the diet was not supplemented with lysine.

## Protein efficiency ratio (PER)

The values of the average protein efficiency ratio are shown in Table 6. Significant differences (P < 0.05) were obtained which did not follow any particular pattern. PER is a clear indicator of the quality of dietary protein. Dietary protein quality can be assessed by its availability for tissue deposition. Significant difference observed between dietary treatments is not directly linked to reduced intestinal absorption of amino acids due to increasing CSC in dietary treatment which essentially is as a result of the interference of anti-nutritional factor resulting in increased nitrogen excretion and consequently reduced protein utilization. Jaffe and Vagalette (1968), Pusztai et al. (1981) Grant et al. (1983) reported that decrease in

**Table 7.** Haematology of birds fed cotton seed cake based diets from 0 to 8 weeks of age.

| Treatment | HAEMATOLOGICAL PARAMETERS[1] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | PCV (%) | Hb (g/100ml) | RBC ($2.9x10^{12}$ $m^3$) | WBC ($x10^6/mm^3$) | Lym (%) | Neu (%) | Eos (%) | Mono (%) |
| 1 | 30.17[a] | 9.65 [ab] | 2.67 | 2.32 | 46.33[ab] | 52.33 [ab] | 2.00 [a] | 1.50 |
| 2 | 29.83[a] | 9.67 [ab] | 3.30 | 1.93 | 54.00[a] | 44.83 [b] | 1.00[b] | 2.00 |
| 3 | 27.83[ab] | 10.6 [ab] | 3.27 | 2.22 | 45.83 [ab] | 53.00 [ab] | 1.00[b] | 1.33 |
| 4 | 26.17[b] | 8.48[b] | 3.23 | 1.90 | 47.33 [ab] | 52.33 [ab] | 1.00 [b] | 2.00 |
| 5 | 31.00[a] | 10.18 [ab] | 3.23 | 1.90 | 35.17 [b] | 64.00 [b] | 1.00[b] | 1.50 |
| SEM | 1.16 | 0.42 | 0.28 | 0.18 | 4.58 | 4.51 | 0.04 | 0.25 |

ab: Means in the same column with different superscripts are significantly different (P < 0.05).
[1]PCV = Packed Cell Volume, Hb = Haemoglobin, WBC = White Blood Cells, Lym = Lymphocytes, Neu = Neutrophils, Eos = Eosinophils, and Mono = Monocytes

net protein utilization (NPU) values of oilseed cakes could be attributed to their haemaglutinizing properties.

The major anti-nutrient in CSC, gossypol, is known to form a complex with protein limiting their digestion and utilization for tissue deposition. Ikurior and Fetuga (1984), Aletor et al. (1990), Fernandez et al. (1994) and Gamboa et al. (1997) who reported reduced digestion of amino acids except methionine, arginine and histidine in a heat-treated CSC-based diet support the report of these previous authors.

## Haematological parameters

The haematological parameters of broilers fed CSC-based diets for 8 weeks are presented in Table 7. Packed cell volume showed significant differences ($P < 0.05$) between the dietary treatments. The lowest value was obtained from treatment 4 (26.17%) which was signifcantly lower than treatments 1 and 5. Haemoglobin followed the same pattern as PCV with treatment 5 (10.18) not being significantly different from treatment 1 (9.65). And the lowest value came from treatment 4 (8.48). The result of the red blood cells (erythrocyte number) did not show any significant difference ($P > 0.05$) between dietary treatments. The lowest numerical value came from treatment 1 (2.67) while the highest value was from treatment 2 (3.30). The white blood cell count did not show any significant ($P > 0.05$) difference between the treatments.

Lymphocytes, also known as the differential count gave significantly different values ($P < 0.05$) between the dietary treatments. The highest value came from treatment 2 (54.00%) while lowest was from treatment 5 (35.17%) which was significantly ($P < 0.05$) lower than all the other. Neutrophils values obtained showed significant ($P < 0.05$) difference between the treatment means. The amount of neutrophils was higher in treatment 5 (64.00%) than all others while treatment 2 gave the lowest (44.83%). Results from Eosinophils showed that treatment 1 (2.00%) was significantly ($P < 0.05$) different from all the others which had almost the same value of 1.00%. Results obtained from monocytes did not show any significant differences among the treatment means. Values obtained from both treatments 2 and 4 were the highest which were 2.00% and 2.00% respectively, while the lowest value was from treatment 3 (1.33%).

Tewe et al. (1991) stated that the purpose of investigating blood composition is to have a way of distinguishing normal states from a state of stress in an animal. Such stress factors can be inadequate nutrition, poor management, environmental or physical stress. The function of the blood in transporting hormones, metabolites, as thermo-regulators and general homeostasis has been clearly established (Duke, 1985). Diets have been reported to have significant influence on haematological variables (Veulterinora, 1991). The haematological parameters (Table 7) for the treatments were similar only for Red blood cells (RBC), White blood cells (WBC) and monocytes. All others had significant differences. The values of the PCV of treatment 1 (control) and treatment 5 were within the normal range (31 - 33.5%) reported for broilers after six weeks of age by Mitruka and Rawnsely (1977) while others fell below it, only treatment 4 was significantly lower than the others. Generally, the results indicate the good health status of the birds as low PCV values are taken to indicate anaemia. This work agrees with the work of Adejimi et al. (2000) who fed broilers with varying levels of soldier fly larvae meal. Similar values were also obtained by Akinmutimi and Onwudike (2001).

The results obtained for Haemoglobin (Hb) followed the same pattern with that of PCV with values from treatment 4 significantly lower than the others. This shows that CSC-based diets are nutritionally adequate to meet the protein needs of the birds since the Hb concentrations decreased in animals on low protein intake, parasite infection or liver damage (Lindsay, 1977). This result also suggests that the blood of the birds had an appreciable oxygen carrying capacity which shows that nutrient transport by the blood was not impaired by feeding CSC. Church et al. (1984), Babatunde et al. (1987) showed that PCV and Hb are correlated with the nutritional status of

**Table 8.** Serum constituents of broilers fed CSC-based diets from 0 to 8 weeks of age (g/ 100 ml of blood).

| Treatment | Total protein | Albumin | Globulin | ALB : GLB |
|---|---|---|---|---|
| 1 | 11.93$^{b}$ | 4.36$^{b}$ | 7.57$^{a}$ | 0.58$^{b}$ |
| 2 | 10.65$^{c}$ | 5.41$^{ab}$ | 5.24$^{c}$ | 1.03$^{a}$ |
| 3 | 12.72$^{a}$ | 6.24$^{a}$ | 6.48$^{b}$ | 0.81$^{b}$ |
| 4 | 12.91$^{a}$ | 5.47$^{ab}$ | 7.44$^{a}$ | 0.74$^{b}$ |
| 5 | 10.45$^{c}$ | 4.68$^{b}$ | 5.77$^{c}$ | 0.81$^{b}$ |
| SEM | 1.58 | 1.13 | 1.19 | 0.16 |

**abc**: Means in the same column with different superscripts are significantly different (P < 0.05).

the animal which directly relate to the nutritional balance of the diet fed to the animal.

The RBC values for birds showed no significant differences among dietary treatments. Values of RBC obtained fell within the normal range reported by Mitruka and Rawnsely (1977) and those of Olorode et al. (1996). But it does not agree with the work of Adejinmi et al. (2000) who reported inconsistent RBC values for broilers fed varying levels of soldier fly larvae meal diets. This suggests that CSC-based diets did not inhibit haemopoiesis as would have been the case if the gossypol had inhibited protein digestion. A progressive degradation of erythrocytes because of the presence of anti-nutrients might not have occurred as postulated by Ikegwuonu and Basir (1977). White blood cell values for the birds fed CSC-based diets followed the same pattern with RBC. The leucocytes values were not significantly different from each other. This shows that the birds ability to fight disease invasion, phagocytosis was not impaired by the diets. The values for the differential counts (lymphocytes and neutrophils) showed significant differences within treatments and values were slightly above the normal range reported by Olorode et al. (1996).

Eosinophils (Eos), which are known to phagocytize particles formed when an antigen and antibodies react, for the control were significantly better than the other treatments. Monocytes which closely resembles the neutrophils in that they are actively motile, phagocytic in action, leaves the blood stream to ingest micro organisms and other foreign material which may be introduced into the tissues did not show any significant differences between the treatments.

The high values for lymphocytes, neutrophils and monocytes suggest the resistance of the birds in disease conditions. For example high lymphocyte values would be recorded in viral and bacterial infection such as coccidiosis, high neutrophil values would be recorded in parasitic infection e.g. lice, while high monocytes values would be recorded in instances of injury to body tissues. Therefore, the total replacement of SBC protein with CSC in the diets of broilers did not influence their physiological and pathological status adversely.

## Serum biochemistry

The results of the biochemical estimations of serum total protein, albumin and globulin are presented in Table 8. The serum total protein values obtained showed that there were significant (P < 0.05) differences between treatment means. The highest value for the albumin was recorded for the birds in treatment 3 (6.24) which showed significant (P < 0.05) differences between treatments. Significant differences (P < 0.05) were recorded for the globulin of the birds in the different treatments. The albumin to globulin (alb/Glb) ratio similarly showed significant changes (P < 0.05) with the treatments although there was no particular trend. Total serum protein concentration was not adversely affected by replacement level of up to 75% CSC for SBC protein in the diets. Beyond this replacement level a depression in the utilization of protein was observed. Reddy and Salunkhe (1984) reported decreases in total protein attributable to inhibition of protein utilization in broilers. However, the 75% replacement of SBC protein with CSC is an indication of the efficient use of the protein in the diet, Chandra et al. (1983) and Adejinmi et al. (2000) made similar observations even though their values were slightly lower.

The Total protein, Albumin and Globulin values recorded in this study attest to the nutritional adequacy of CSC in meeting the protein needs of the birds except those in treatment 5. The candid observation from this work shows that 75% CSC protein can conveniently replace the same amount in SBC in a properly formulated diet to meet the nutritional needs of the broiler birds.

## Carcass analysis

Results of carcass characteristics are shown in Table 9. Significant (P < 0.05) differences in weight gain were observed at the end of the study. Live weight ranged from 1.60 to 2.10 kg. However, on the average treatments 2, 4 and 1 (control) had higher weights than the other treatments. The bled weight expressed as percentage of the live weight did not show any significant difference (P

**Table 9.** Carcass characteristics of broilers fed CSC- based diets from 0-8 weeks.

| Body Parts/Organs | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | SEM |
| Live weight (kg) | 2.10[a] | 1.95[a] | 1.83[ab] | 1.95[a] | 1.60[b] | 0.08 |
| Bled weight .(expressed as % of live weight) | 98.57 | 98.97 | 98.36 | 98.46 | 98.88 | 2.02 |
| Plucked wt (expressed as % of live weight) | 92.29[a] | 91.28[a] | 91.25[a] | 92.30[a] | 86.88[b] | 2.01 |
| Dressed wt .(expressed as % of live weight) | 70.00[a] | 73.33[a] | 69.94[a] | 70.25[a] | 65.63[b] | 3.07 |
| GIT (expressed as % of dressed weight) | 20.41 | 18.18 | 18.18 | 19.71 | 26.66 | 5.12 |
| Liver(expressed as % of dressed weight) | 4.12 | 3.23 | 3.99 | 4.00 | 4.57 | 0.69 |
| Heart (expressed as % of dressed weight) | 0.66 | 0.69 | 0.60 | 0.58 | 0.78 | 0.07 |
| Gizzard (expressed as % of dressed weight) | 3.54 | 3.75 | 4.28 | 4.16 | 5.18 | 1.17 |

**ab**: Means in the same column with different superscripts are significantly different (P<0.05).
% L W = Percentage Live weight.
GIT = Gastro-intestinal tract.

< 0.05). Values ranged from 96.88 to 98.97 %. The plucked weight expressed as percentage of live weight showed significant differences (P < 0.05) among treatments. Values for plucked weight ranged from 86.88 to 92.30 %. The dressed weight also expressed as a percentage of the live weight ranged from 65.63 to 73.33 %. The value for treatment 5 was significantly (P < 0.05) lower than all the others. The gastro-intestinal tract (GIT), liver, heart, gizzard and all other body parts measured were expressed as percentages of dressed weight of the birds for each treatment. No significant difference (P > 0.05) was recorded for these body parts and organs.

The plucked and dressed weights expressed as percentage of live weight followed the same pattern, with the live weight of birds on treatment 5 being significantly lower than others. This implies that up to 75% CSC replacement for SBC protein will not affect the dressing percentages of the birds. This does not agree with the work of Bamgbose (1996) who reported an adverse effect on performance and carcass quality when CSC replaced GNC at 50 and 100% replacement levels.

Values obtained for the liver, heart and gizzard did not show any significant difference clearly showing that the free gossypol in the fed CSC did not cause liver cirosis. The effort by the heart in meeting up with the need of oxygenated blood for detoxification would have caused its enlargement or damage. For the gastro-intestinal tract and the gizzard, bulk handling due to increased fibre content of ration has been reported to affect the weight positively. In this work, fibre content of diets increased progressively, but was not above that recommended for broilers (NRC, 1994) and also did not significantly affect the gut dimensions though numeric differences were observed.

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