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# Effect of replacing wheat offal with soybean chaff on the growth response, blood profile and carcass yield of finishing broiler chickens

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ADDITIONAL KEYWORDS

Broilers.
Alternative feedstuffs.
Soybean chaff.
Haematology.
Carcass yield.
Sensory properties.

## SUMMARY

A 5-week feeding study was conducted to evaluate the suitability of soybean chaff (SC) as a replacement for wheat offal in the diets of broiler chickens. A total of three hundred and sixty (360), 21-d-old mixed sexes, broiler chickens were weighed individually and randomly assigned to 1 of 3 dietary treatments with 8 replicate pens and 15 birds per replicate in a completely randomized design. Dietary treatments consisted of maize-soybean based diets containing 0, 50, 100% SC as replacement for wheat offal. Data generated on growth performance, blood indices, carcass yield and sensory properties of finishing broiler chickens were analyzed by ANOVA using PROC GLM of SAS (2007). Results showed that higher (P<0.05) final weight and daily weight gain were obtained in birds fed 100% SC and control diet. However, Feed conversion ratio (FCR), livability, European Production Efficiency Factor (EPEF) and European Broiler Index (EBI) were not significantly (P>0.05) affected. Birds fed 100% SC had higher (P<0.05) live weight, plucked weight, wings and empty gizzard weight compared to other treatments. Replacement of wheat offal with soybean chaff did not interfere with the organoleptic properties of broiler meat. More so, birds fed 100% SC had least cost of feed, cost of feed per weight gain and most profitable commercial value as revealed by reduced total cost of production. Therefore, soybean chaff could be used to completely replace wheat offal as dietary fibre source in the diets of broiler chickens.

**Efecto del reemplazo de los despojos de trigo con paja de soja en la respuesta de crecimiento, perfil sanguíneo y rendimiento de la carcasa de pollos de engorde**

PALABRAS CLAVE ADICIONALES

Pollos de engorde.
Piensos alternativos.
Paja de soja.
Hematología.
Rendimiento de la canal.
Propiedades sensoriales.

## RESUMEN

Se realizó un estudio de alimentación de 5 semanas para evaluar la idoneidad de la paja de soja (SC) como reemplazo de los despojos de trigo en las dietas de pollos de engorde. Un total de trescientos sesenta (360), 21 días de edad, pollos de engorde se pesaron individualmente y se asignaron aleatoriamente a 1 de 3 tratamientos dietéticos con 8 plumas repetidas y 15 aves por repetición en un diseño completamente aleatorizado. Los tratamientos dietéticos consistieron en dietas basadas en maíz y soja que contenían 0, 50 y 100% de SC como reemplazo de los despojos de trigo. Los datos generados sobre el rendimiento de crecimiento, los índices de sangre, el rendimiento de la canal y las propiedades sensoriales de los pollos de engorde de acabado se analizaron mediante ANOVA usando PROC GLM de SAS (2007). Los resultados mostraron que un mayor peso final (P <0.05) y ganancia de peso diaria se obtuvieron en aves alimentadas con SC al 100% y dieta de control. Sin embargo, la tasa de conversión alimenticia (FCR), la habitabilidad, el Factor de Eficiencia de Producción Europea (EPEF) y el Índice de Broiler Europeo (EBI) no se vieron afectados significativamente (P> 0.05). Las aves alimentadas con SC al 100% tenían un peso vivo (P <0.05) más alto, peso desplumado, alas y peso de molleja vacía en comparación con otros tratamientos. La sustitución de los despojos de trigo con paja de soja no interfirió con las propiedades organolépticas de la carne de pollo de engorde. Más aún, las aves alimentadas con 100% de SC tenían el menor costo de alimentación, el costo de alimentación por ganancia de peso y el valor comercial más rentable como lo revela el menor costo total de producción. Por lo tanto, la paja de soja podría usarse para reemplazar completamente los despojos de trigo como fuente de fibra dietética en las dietas de los pollos de engorde.

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## INTRODUCTION

The quest to sustain and even increase the contribution of poultry meat to human protein intake towards achieving food security necessitates the need to employ various feeding strategies to optimize the genetic potential of modern fast-growing broiler strains. Provision of high-quality, nutritionally-adequate and least-cost diets formulated from less competitive and available feed resources that are of social, economic and ecological benefits have greater potential to ensure sustainable broiler production. Although majority of broiler diets is usually cereals and legumes based, the use of alternative feedstuffs which are not staple food for man has been advocated to be used in feeding broilers (Agbede *et al*. 2005; Oke *et al*. 2015).

The role of dietary fiber in broiler nutrition cannot be overlooked owing to its nutritional and physiological functions (Sarikhan *et al*. 2010). Dietary fibre (DF) encompasses very diverse carbohydrate polymers, including polysaccharides, oligosaccharides, lignin, arabinoxylan, inulin, pectin, bran, cellulose, β-glucan and resistant starch, that are resistant to digestion by endogenous enzymes and absorption in the small intestine with complete or partial fermentation in the large intestine (Champ *et al*. 2003; Sarikhan *et al*. 2010; Mateos *et al*. 2012). DF influences gut motility and hind-gut microbial profile thus play critical role on transit time of digesta, interaction between the digesta and secreted biomolecules in the gut, microbial ecology as well as enzymatic and microbial digestion. Previous studies have shown that inclusion of DF in moderate quantity caused significant improvement in digestive organ development and functionality, enhanced secretion of HCl, bile acids, and endogenous enzymes thereby resulted in better gut health, higher apparent nutrient digestibility, and improved growth performance (Mateos *et al*. 2012). However, response of poultry birds to DF depends largely on the physicochemical properties of fibre, composition of the basal diet, feed form and particle size, the type and age of the birds, as well as the physiologic and health status of the birds (Mateos *et al*. 2012).

Wheat offals, a by-product of wheat flour milling, is a common fibre source in broiler diets. It contains considerable amounts of energy and proteins which may be present as intracellular compounds (Liu and Baidoo, 2005). Oke *et al*. (2015) reported that wheat offal contained 914.6, 229.6, 35.9, 39.7, 52.6, 368.7, 155.3, and 538.6 g/kg dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF), crude ash (CA), neutral detergent fibre (NDF), acid detergent fibre (ADF) and nitrogen free extract (NFE), respectively. However, consumption of whole wheat flour due to increasing awareness on functional fibers for humans makes it relatively scarce thus commanding competitively higher market price. In search for alternative, soybean chaff is recognized as a suitable replacement.

Soybean chaff (also known as soybean pod husk) is the by-product usually obtained when the seeds have been mechanically or manually harvested and trashed (Sruamsiri and Silman, 2008). Nutritional evaluation of soybean chaff showed that it contained 911.1, 50.4, 16.5, 601.5, 420.8, 12.1, 0.6 g/kg, and 3980 kcal/kg DM, CP, EE, NDF, ADF, Ca, P, and gross energy, respectively (Sruamsiri and Silman, 2008). Previous work have shown that Soybean chaff could serve as suitable supplement or alternative feed for beef cattle during the dry season when forages are scarce owing to its higher DM, ADF and NDF digestibilities, total digestible nutrients (TDN), and digestible energy when compared with guinea grass (Sruamsiri and Silman, 2008). Meanwhile, there is a dearth of information in literature on utilization of soybean chaff as a feedstuff for non-ruminant animals especially broiler chicken. To this end, the study was designed to investigate the response of broiler chickens in terms of growth performance, blood profile and carcass yield to different dietary fiber source by replacing wheat offal with soybean chaff.

## MATERIAL AND METHODS

### Experimental site and study protocol

The feeding trial was conducted at the Poultry Unit of the Teaching and Research Farms, Federal University of Agriculture, Abeokuta, Nigeria (Latitude 7° 13’ 49.46”N and Longitude 3° 26’ 11.98”E). Experimental procedures in the present study were in accordance with the guidelines of the Animal Care and Use Review Committee of the College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria.

### Experimental design and diets

The test ingredient (Soybean chaff) was sourced from the Nestle Plc, Agbara, Ogun State, Nigeria. Thereafter, it was milled and kept until ready for incorporation into formulated diets. Wheat offal and other feed ingredients were purchased from a commercial feed mill (Jeje Feeds, Abeokuta, Ogun State). The experimental diets were formulated in accordance with the NRC (1994) requirements for Broiler Chickens (**Table I**). Soybean chaff replaced wheat offal at 0, 50, and 100% on weight equalization basis to form 3 dietary treatments. The cost of feed was based on the prevailing market price of ingredients at the time of the study. The diets were presented to the birds in mash form.

### Birds and management procedures

A total of 360, one-day-old, unsexed, broiler chicks used in this study were obtained from a commercial hatchery (NuBreed Farms, Abeokuta, Nigeria). On arrival from the hatchery, they were randomly allotted to 12 pens where they were brooded and reared together under a deep litter intensive housing system for a 21-d pre-experimental period. During this period, birds were fed with a commercial broiler starter mash (ME: 2950 Kcal/kg; CP: 21.50%, EE: 3.50%; CF: 3.75%; Lys: 1.12%; Met: 0.51%; and Trp: 0.21%). Feed and clean water were supplied unrestrictedly.

At d 21, birds of similar weights were randomly assigned to one of 3 dietary treatment groups with 8 replications. Each replicate group had 15 birds. Thereafter, the feeding trial commenced (on d 22) and lasted for 5 weeks. Throughout the rearing period, dried wood shavings were used as litter material. Feed and clean water were offered *ad libitum.* Birds received Infectious Bursal Disease Vaccines (IBDV) and Newcastle Disease Vaccines (NDV Lasota) while other regular medications were strictly adhered tofunc

### Growth performance

During the experiment, feed intake was measured as the difference between the feed offered and leftovers

**Table I. Gross composition of experimental diet (4-8 weeks)** (Composición bruta de la dieta experimental (4-8 semanas).

| Ingredients (%) | T1 | T2 | T3 |
|---|---|---|---|
| Maize | 56.00 | 56.00 | 56.00 |
| Soybean meal | 27.00 | 27.00 | 27.00 |
| Wheat offal | 10.00 | 5.00 | 0.00 |
| Soybean shaft | 0.00 | 5.00 | 10.00 |
| Fishmeal (72% CP) | 2.50 | 2.50 | 2.50 |
| Limestone | 1.50 | 1.50 | 1.50 |
| Dicalcium phosphate (DCP) | 2.00 | 2.00 | 2.00 |
| L-Lysine HCl | 0.10 | 0.10 | 0.10 |
| DL-Methionine | 0.20 | 0.20 | 0.20 |
| Industrial Salt (NaCl) | 0.35 | 0.35 | 0.35 |
| Vitamin/Minerals Premix[1] | 0.25 | 0.25 | 0.25 |
| Toxin binder[2] | 0.10 | 0.10 | 0.10 |
| Total | 100.00 | 100.00 | 100.00 |
| Calculated analysis | | | |
| ME (Kcal/Kg) | 2932.48 | 2968.06 | 3005.13 |
| CP (%) | 20.44 | 20.14 | 19.84 |
| Methionine (%) | 0.53 | 0.53 | 0.53 |
| Lysine (%) | 0.98 | 0.95 | 0.92 |
| Ca (%) | 1.23 | 1.22 | 1.22 |
| Cost (₦/kg feed)[3] | 102.59 | 100.09 | 97.59 |

[1]Each 2.5kg Vitamin & Trace Minerals Premix for Broiler Finisher contains vitamin A: 8,000,000IU, Vit D3: 1,600, 000IU, Vit E: 20,000IU, Vit K: 2,000mg, Vit B1: 1, 500mg, Vit B2: 4,000mg, Vit B6: 2,500mg, Vit B12: 10mcg, Niacin 15,000mg, Panthothenic acid: 5,000mg, Folic acid: 500mg, Biotin: 20mcg, Choline chloride: 200,000mg, Manganese: 80,000mg, Zinc: 50,000mg, Iron: 20,000mg, Copper: 5,000mg, Iodine: 1,000mg, Selenium: 200mg, Cobalt: 500mg, Antioxidant: 120,000mg. Produced by Rotinol International Ltd, Ogun State, Nigeria. [2]Manufactured by Biofeed Technology Inc., Canada, [3]Cost of feed based on prevailing market price at the time of experiment.

while live weight of the birds per replicate were measured on weekly basis. Then, weight gain was computed as the difference between the final live weight and initial weight at the commencement of the study. Feed conversion ratio (FCR) was computed as the ratio of feed consumed to weight gain. A record of mortality was kept as it occurred in order to determine livability. European Production Efficiency Factor (EPEF) and European Broiler Index (EBI) were estimated using the following formulae:

### Haematological and serum biochemisry indices

At the expiration of the feeding trial (d 56), blood samples were collected with needle and syringe through the jugular vein of two birds per replicate ($n$ = 16 per treatment). About 2.5 ml each was collected in EDTA bottles and plain bottles without anti-coagulant for the determination of haematological indices and serum biochemical analysis, respectively. Haematological indices such as Packed cell volume (PCV), Haemoglobin concentration (Hb), Red blood cell (RBC), and White blood cell (WBC) counts were determined according to the routine haematological procedures for avian (Weiss and Wardrop, 2010; Fafiolu *et al*. 2014). Serum levels of total protein (biuret method), albumin (bromocresol green method), uric acid (Trinder's enzymatic method) and glucose levels were determined using Cobas Mira Automatic Analyzer (Roche Diagnostis System, Basel, Switzerland) at $37^0$C with the aid of commercial kits (Labtest Diagnostica®, Lagoa Santa, MG, Brazil). Samples reading were performed using spectrophotometry with light wavelength adequate for each test, as described by Fafiolu *et al*. (2014). Serum globulin values were estimated based on the difference between the concentrations of total protein and albumin.

### Carcass yield evaluation

At d 56, two birds per replicate ($n$ = *16* per treatment) whose weight is a representative of the average weight per treatment were selected, slaughtered, defeathered, and eviscerated following standard commercial procedures. The body weight and dressed weights were measured while the carcass (dressing) percentage was calculated. Primal-cut parts, such as breast, drumsticks, thighs, and wings were weighed. The organs, which include liver, heart, spleen, and empty gizzard were collected and weighed using a sensitive digital electronic weighing scale (CAMRY; Model EK 3250). The weights were expressed as percentage of respective live weights.

### Sensory evaluation

At the end of the feeding trial, organoleptic properties of breast meat from broiler chickens were assessed. Samples were drawn from dressed chickens after carcass evaluation. 15 pieces of chicken breast fillet samples were taken from each treatment group, sliced into 1 cm thickness, and prepared using a wet cooking method. Meat samples were cooked in an aluminium pot containing 500mls of water with 3 g of common salt, without any other spices added, for 10 minutes. Sensory properties of anonymous samples (about 10g each) was analyzed using 9-point Hedonic scale by 15 trained panelists. The order of presentation of samples to the panel was randomized. Tap water was provided to rinse the mouth between evaluations. The panelists were well instructed on the assessment criteria and meat attributes to be rated. Panelists evaluated the coded samples for appearance, flavour, colour, juiciness, taste, tenderness, and overall acceptability on 9-point scale where 1 (the least preferred) and 9 (the most preferred) were the extremes of each characteristics.

### Chemical and statistical analyses

Test ingredients and experimental diets were analyzed in triplicates after samples were grounded using the standard methods of the Association of Official

**Table II. Proximate analysis of wheat offal, soybean chaff and experimental diets** (Análisis proximal de despojos de trigo, paja de soja y dietas experimentales).

| Parameters (%) | Wheat offal | Soybean chaff | T1 (Control) | T2 (50% SC) | T3 (100% SC) |
|---|---|---|---|---|---|
| Dry matter | 87.00 | 87.94 | 89.15 | 88.97 | 88.53 |
| Crude protein | 15.61 | 17.06 | 21.15 | 21.23 | 21.26 |
| Crude fiber | 10.00 | 35.64 | 3.74 | 4.90 | 5.86 |
| Ether extract | 5.14 | 0.99 | 3.72 | 3.57 | 3.44 |
| Crude ash | 6.40 | 2.87 | 3.32 | 3.24 | 3.15 |
| Nitrogen free extract (NFE) | 49.85 | 31.38 | 55.22 | 56.01 | 54.82 |
| Calcium | 0.14 | 0.15 | 1.18 | 1.17 | 1.19 |
| Phosphorus | 1.20 | 1.33 | 0.63 | 0.67 | 0.76 |

#Mean values on 3 replicates

Analytical Chemists (AOAC, 1990). Moisture content as dry matter (DM; 934.01), ether extract (EE; 920.39), crude ash (CA; 942.05), crude protein (CP; 976.05), crude fibre (CF; 978.10), Calcium (Ca; 935.13), and phosphorus (P; 964.06) were determined while soluble carbohydrate (Nitrogen free extract; NFE) was estimated using the expression; NFE = 100 − (CF + EE + CP + CA + moisture).

Data generated from this study were subjected to One-Way Analysis of Variance technique in a completely randomized design using General Linear Model procedure of SAS (2007) (SAS for Windows, 9.1.3 portable version, Cary, NC, USA). Differences between means were determined by Tukey's HSD test at $P<0.05$ level of significance. The statistical model used was:

$Y_{ij}$ = Observed value

$S_i$ = Effect of $i^{th}$ wheat offal replacement with soybean chaff (i = 0, 50, & 100%)

$E_{ij}$ = Random error associated with each record

## RESULTS

The effect of wheat offal replacement with soybean chaff on performance of finishing broiler chickens (22 – 56 d) are shown in **Table III**. Higher (P<0.05) final weight and daily weight gain were obtained in birds fed 100% SC and control diet while birds fed 50% SC (T2) had least values. Highest (P<0.05) daily feed intake was observed in birds fed control diets (135.53 g/bird) while those fed 50% SC (T2) had lowest feed intake (121.36 g/bird). However, FCR, livability and production performance index such as European Production Efficiency Factors (EPEF) and European Broiler Index (EBI) were not significantly (P>0.05) affected by the dietary treatments.

Influence of dietary treatments on haematological indices of broiler chickens as shown in **Table IV** revealed that haematological indices investigated were significantly (P<0.05) affected. Higher (P<0.05) PCV (36.00%), Hb (11.50%), RBC (3.05 ($x10^{12}$/L) and WBC (11.40 ($x10^{9}$/L) values were obtained in birds fed T1 while the lowest values were obtained in birds fed T3. This showed that haematological values of chickens decreased with increasing soybean chaff inclusion level. The effect of replacing wheat offal with soybean chaff on serum biochemistry of broiler chickens at the finisher phase is shown in **Table V**. The results revealed that dietary treatment had no significant (P>0.05) influence on all serum biochemical indices investigated except (P<0.05) for glucose. Higher (P<0.05) and lowest serum glucose values were observed in birds fed diets T2 and T1, respectively.

The results of carcass yield of broiler chickens as influenced by replacement of wheat offal with soy-

**Table III.** Effect of soybean chaff on performance of finishing broiler chickens (4-8 weeks) (Efecto de la paja de soja en el rendimiento del acabado de pollos de engorde (4-8 semanas).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| Final weight (g) | 2315.00[a] | 2180.00[b] | 2370.00[a] | 30.46 | 0.0028 |
| Initial weight (g) | 533.33 | 536.67 | 550.50 | 13.84 | 0.5539 |
| Daily weight gain (g) | 50.91[a] | 46.95[b] | 51.43[a] | 0.82 | 0.0169 |
| Daily feed intake (g/bird) | 135.53[a] | 121.36[c] | 131.21[b] | 2.13 | <0.0001 |
| FCR | 2.66 | 2.59 | 2.55 | 0.03 | 0.2694 |
| Livability (%) | 100.00 | 100.00 | 98.41 | 0.35 | 0.0787 |
| EPEF | 248.45 | 241.01 | 261.35 | 4.39 | 0.1607 |
| EBI | 191.21 | 181.86 | 198.59 | 4.21 | 0.3017 |

[a,b,c] Mean values having different superscript along were significantly (P<0.05) different. SC: Soybean chaff, SEM: Standard Error of Mean, EPEF: European Performance Efficiency Factor, EBI: European Broiler Index, FCR: Feed conversion ratio.

**Table IV. Effect of soybean chaff on haematological indices of Broiler chickens (d 56)** (Efecto de la paja de soja en los índices hematológicos de pollos de engorde (d 56).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| PCV (%) | 36.00$^{a}$ | 26.50$^{b}$ | 24.00$^{b}$ | 2.176 | 0.0462 |
| Hb (%) | 11.50$^{a}$ | 8.80$^{ab}$ | 8.10$^{b}$ | 0.640 | 0.0410 |
| RBC (x10$^{12}$/L) | 3.05$^{a}$ | 2.28$^{ab}$ | 2.11$^{b}$ | 0.174 | 0.0318 |
| WBC (x10$^{9}$/L) | 14.00$^{a}$ | 11.85$^{b}$ | 10.10$^{c}$ | 0.586 | 0.0004 |

$^{a,b,c}$ Mean values having different superscript along were significantly (P<0.05) different. SC: Soybean chaff, SEM: Standard Error of Mean, PCV: Packed Cell Volume, Hb:Haemoglobin concentration, RBC: Red Blood Cell, WBC: White Blood Cell.

bean chaff are shown in **Table VI**. Dietary treatments produced significant effect (P<0.05) on live weight, wings and empty gizzard. Birds fed T3 (100% SC) had higher (P<0.05) live weight (2.37 kg) while birds fed diets containing T2 (50% SC) had lowest live weight (2.23 kg). Significantly higher (P<0.05) wings value was observed in birds fed T3 diets while the least value was observed in those fed T1 (Control). Highest (P<0.05) value observed for empty gizzard was obtained in birds fed diets containing T3.

The results of sensory properties of broiler chickens fed soybean chaff as replacement for wheat offal are presented in **Table VII**. The use of soybean chaff produced no significant (P>0.05) effect on appearance, flavour, colour, juiciness, taste, tenderness, and overall acceptability of broiler chickens investigated. Inclusion of soybean chaff produced significant (P<0.05) influence on the production economics (**Table VIII**). Cost of feed decreased significantly (P<0.05) with soybean chaff inclusion from ₦102.59k (T1) to ₦97.59k (T3) per kg diet. Highest (P<0.05) cost of feed consumed per bird (₦486.62k) was obtained in birds fed 0% SC (T1) while the lowest cost of feed intake per bird (₦425.14k) was obtained in broilers fed 50% SC (T2). Also, cost of feed per weight gain decreased progressively (P<0.05) from ₦273.13k in birds fed control diet (T1) to ₦249.08k in birds fed 100% SC (T3).

## DISCUSSION

The objective of this study is to evaluate the suitability of soybean chaff (SC) as a replacement for wheat offal in the diets of broiler chickens. The proximate content of soybean chaff used in this study revealed higher crude protein and crude fiber but lesser crude fat and ash when compared with wheat offal (**Table II**). Although soybean chaff has high crude fibre content, the fibre matrix revealed that it has low cell wall and lignin content (ADF) compared with wheat bran and rice bran. Lignin is an undigestible cell wall component in plant and feedstuff, thus tending to limit nutrient digestibility especially of carbohydrate components (Sruamsiri and Silman, 2008). Previous findings have shown that soybean straw is found to be superior in nitrogen content that wheat straw, and that the fiber components contain very low non-structural carbohydrate content which are very digestible and their utilization have yielded consistent results when fed to growing beef and dairy cattle (Marston *et al*. 1993; Wofford *et al*. 1994; Sruamsiri and Silman, 2008). Therefore, soybean chaff which contains soybean pod and short straw could be used in livestock feeding. Variation in the nutrient profile of soybean chaff used in this study and those reported by Sruamsiri and Silman (2008) could be partly attributed to differences in growing conditions of soybean, nature and composition of the chaff, processing techniques adopted, as well as analytical procedures. Meanwhile, there is no wide variation in the nutrient composition of the resultant experimental diets. This indicates its adequacy as suitable alternative to wheat offal in broiler feeds.

Reduced (P<0.05) feed intake in birds fed 100% SC produced similar final weight and daily body gain with birds fed wheat offal. This supports the adequacy of soybean chaff as a viable alternative for wheat offal in diets of broiler chickens. Non-significant difference

**Table V. Effect of soybean chaff on serum biochemistry of finishing broiler chickens (d 56)** (Efecto de la paja de soja en la bioquímica sérica del acabado de pollos de engorde (d 56).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| Total Protein (g/L) | 2.50 | 2.60 | 2.20 | 0.870 | 0.1394 |
| Albumin (g/L) | 1.35 | 1.35 | 1.25 | 0.320 | 0.3944 |
| Globulin (g/L) | 1.15 | 1.25 | 0.95 | 0.078 | 0.3119 |
| Glucose (mg/dL) | 198.75$^{b}$ | 208.50$^{a}$ | 204.00$^{ab}$ | 1.691 | 0.0286 |
| Urea (mg/dL) | 20.50 | 21.00 | 22.50 | 0.520 | 0.2963 |
| AGR | 1.17 | 1.15 | 1.34 | 0.084 | 0.6495 |

$^{a,b}$ Mean values having different superscript along were significantly (P<0.05) different. SC: Soybean chaff, AGR: Albumin Globulin Ratio, SEM: Standard Error of Mean in FCR of broiler chickens fed soybean chaff in this study suggests that utilization efficiency of dietary nutrients for optimum growth is not impaired, thus soybean chaff has potential to be used as fibre source in poultry diets without adverse effects on animal performance. Similarly, non-significance in productive efficacy factors (EPEF and EBI) revealed that the efficacy of rearing the birds would not be hampered by the use of soybean chaff. This results contradicts that of Ali *et al*. (2008) who reported significant difference in weight gain and feed conversion of broiler chickens fed wheat bran based diets supplemented with various additives.

Higher live weight and plucked weight observed in birds fed 100% soybean chaff suggests its appropriateness, and even superiority, as fibre sources in nutrition of broiler chickens in place of wheat offal. This could be an indication that dietary fibre components of Soybean chaff, being plant protein origin, is more soluble and hydrolysable by endogenous enzyme to release more amino acids precursors or substrates needed for muscle protein synthesis compared to non-starch polysaccharides (NSP) fractions in wheat offal. Lawal *et al*. (2012) had reported that plant cell wall contains a variety of polysaccharides which are interlinked with each other by covalent or non-covalent linkages, thus their efficient utilization as dietary fibre sources in poultry diets depend on the efficacy of its conversion into respective peptides or amino acids, oligo or monosaccharide.

Birds fed 100% soybean chaff (T3) had highest (P<0.05) empty gizzard weight compared to other treatments. This suggests that the birds have greater potential for increased nutrient digestion and more efficient feed utilization which led to increased body gain, and probably could be attributed to the higher carcass live weight, plucked weight and wings observed in birds fed such diets. Svihus *et al*. (2004) had noted that a large, well developed gizzard, as occurs with DF inclusion, improves GIT motility, favors gastro duodenal refluxes, and increases cholecystokinin release, which in turn may stimulate the secretion of pancreatic enzymes.

Being the pacemaker organ in birds, gizzard regulates the particle size of food entering the small intestine for downstream digestion, governs many physiological aspects of the GIT including motility regulation, control of feed flow and gastro-duodenal refluxes, enhancement of digestive secretions, including HCl, bile acid, and endogenous enzymes, as well as synchronization of digestion and absorption processes (Mateos *et al*. 2012). In addition, the increased grinding activity of the gizzard together with a better mixing of digestive juices with the digesta attributable to the increase in antiperistaltic movements within the GIT, might explain the positive effects of insoluble DF on the digestibility of dietary components (Jiménez-Moreno *et al*. 2009).

Non-significant difference in carcass yield (dressing percent) and primal cut parts (breast, thigh, and drum-

**Table VI. Effect of soybean chaff on carcass yield of finishing broiler chickens (d 56)** (Efecto de la paja de soja en el rendimiento de la carcasa de pollos de engorde de acabado (d 56).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| Live weight (kg) | 2.32$^{ab}$ | 2.23$^{b}$ | 2.37$^{a}$ | 0.239 | 0.0205 |
| Plucked weight (kg) | 2.15$^{a}$ | 1.68$^{b}$ | 2.20$^{a}$ | 0.098 | 0.0197 |
| Dressed weight (kg) | 1.60 | 1.40 | 1.65 | 0.054 | 0.1250 |
| Dressing % | 69.00 | 62.87 | 69.62 | 1.892 | 0.3087 |
| Primal Cut-Parts (% live weight) | | | | | |
| Breast | 16.02 | 13.61 | 15.29 | 0.509 | 0.1324 |
| Drumstick | 9.92 | 9.40 | 9.85 | 0.151 | 0.3565 |
| Thigh | 5.44 | 5.32 | 5.44 | 0.062 | 0.7024 |
| Wings | 6.55$^{b}$ | 8.33$^{ab}$ | 9.20$^{a}$ | 0.492 | 0.0405 |
| Relative organs weight (% live weight) | | | | | |
| Liver | 1.83 | 2.51 | 2.30 | 0.128 | 0.0615 |
| Heart | 0.39 | 0.56 | 0.46 | 0.041 | 0.2603 |
| Spleen | 0.41 | 0.49 | 0.44 | 0.016 | 0.0813 |
| Empty Gizzard | 2.11$^{b}$ | 1.93$^{b}$ | 2.65$^{a}$ | 0.126 | 0.0145 |

$^{a,b}$ Mean values having different superscript along were significantly (P<0.05) different. SC: Soybean chaff, SEM: Standard Error of Mean.

stick) indicates that the dietary treatment is adequate for maintaining broiler meat production. This findings is supported by those of Donkoh *et al*. (2003) and Ali *et al*. (2008) who reported no significant difference in carcass yield of broiler chickens fed ground maize cob and wheat bran based diets supplemented with additives, respectively.

Assessment of blood profile provides an important index to evaluate their nutritional, clinical and health status of broiler chickens because the blood serves as a medium of transporting nutrients absorbed from the digestive system or released from storage in adipose tissues or in liver. It also provides insight into primary physiological functions of some vital organs such as liver and kidney (Fafiolu *et al.* 2014). The treatment imposed in this study produced significant difference on haematological indices of broiler chickens. Soybean chaff inclusion caused significant decrease in PCV, RBC and WBC. Adeyemi *et al*. (2000) had earlier reported that haematological parameters of broiler chickens could be influenced by the quality of the diets, age, stress, and disease conditions. The broiler chickens did not show any clinical sign of anaemia during the feeding trial which implies the adequacy of dietary nutrients for normal blood cells production. This probably could be attributed to the fact that the values obtained fall within the physiological range reported for poultry birds (Weiss and Wardrop 2010; Fafiolu *et al.* 2014). Benerjee (2008) reported normal blood values for domestic fowl as 25-45%, 2-4 x $10^6$ $mm^3$, 7-13g/dL, and 9-31x$10^3$/uL for PCV, RBC, Hb, and WBC, respectively while Weiss and Wardrop, (2010) reported that haematological values of chickens as 22 – 35 % for PCV, 25 – 35 x $10^5$/uL for RBC, 7-13g/dL for Hb, and 12–30x$10^3$/uL for WBC.

Serum biochemistry profile provides insight to efficiency of dietary protein utilization and functionality of specific organs that are involved in protein metabolism and detoxification. It is therefore being used for tentative diagnosis in farm animals. In this present study, of all serum biochemical constituents (total protein, albumin, glucose and uric acid) examined, only serum glucose was affected ($P<0.05$). This suggests that the fibre matrix of soybean chaff is more susceptible to enzymatic and microbial degradation by endogenous enzymes and hind-gut microbiota, respectively thereby releasing the bound peptides or amino acids, glucose and volatile fatty acids in the complex plant materials for optimum utilization by the birds. Also, this could be partly connected to better weight gain despite the reduced feed intake in birds fed diets containing 100% soybean chaff. Adeyemi *et al*. (2000) had earlier reported that there is a positive correlation between dietary protein quality and serum biochemical constituents.

Non-significance in serum globulin is a pointer that there is no serious clinical or sub-clinical infections that could warrant abnormal increase in immunoglobulin production. According to Agboola *et al*. (2013), globulin carries essential metals through the bloodstream to the various parts of the body and helps the body to fight infections. Also, similar ($P>0.05$) serum urea concentration among treatments confirms normalcy in the digestion, absorption and utilization of protein in the test ingredient without any harmful effect on the functionality of liver and kidney. Agboola *et al*. (2013) reported that serum urea can be used as a test of renal function, protein breakdown, hydration status, and liver failure.

Sensory analysis is one of the oldest and, perhaps still, the essential means of food quality control assessment as it enables manufacturers to identify, understand and respond to consumer preferences more effectively. Sensory evaluation is defined as a scientific method used to evoke, measure, analyze and interpret those responses to products perceived through senses of sight, smell, touch, taste and hearing (Stone and Sidel, 2004). Consumer's preference in terms of leanness, colour, dryness, tenderness, taste and flavour of meat differs. Hence, there is a need to evaluate organoleptic properties which influence the consumer's willingness to regularly purchase and eat meat. The ranking test conducted in this study revealed that experimental diets did not interfere ($P>0.05$) with the organoleptic properties of broiler meat. This is an indication that broiler chickens reared with soybean chaff would be accep-

**Table VII. Effect of soybean chaff on sensory evaluation of broiler chickens** (Efecto de la paja de soja en la evaluación sensorial de pollos de engorde).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| Appearance | 8.67 | 7.33 | 8.33 | 0.190 | 0.0604 |
| Flavour | 8.17 | 7.83 | 8.67 | 0.201 | 0.2680 |
| Colour | 8.17 | 8.00 | 7.83 | 0.214 | 0.8347 |
| Juiciness | 8.33 | 7.17 | 8.00 | 0.218 | 0.0698 |
| Taste | 8.50 | 8.00 | 8.83 | 0.166 | 0.1156 |
| Tenderness | 8.33 | 7.83 | 8.50 | 0.222 | 0.4707 |
| Overall Acceptability | 8.83 | 8.17 | 8.50 | 0.167 | 0.2781 |

SC: Soybean chaff, SEM: Standard Error of Mean.

**Table VIII.** Effect of soybean chaff on cost implication of broiler production (Efecto de la paja de soja en la implicación de costos de la producción de pollos de engorde).

| Parameters | T1 (Control) | T2 (50% SC) | T3 (100% SC) | SEM | P-Value |
|---|---|---|---|---|---|
| Total feed intake (kg) | 4.74[a] | 4.25[c] | 4.59[b] | 7.45 | <0.0001 |
| Cost of feed (₦/kg) | 102.59[a] | 100.09[b] | 97.59[c] | 0.72 | <0.0001 |
| Cost of feed consumed (₦/bird) | 486.62[a] | 425.14[c] | 448.17[b] | 9.06 | <0.0001 |
| Cost of feed/weight gain (₦/kg) | 273.13[a] | 259.04[ab] | 249.08[b] | 4.11 | 0.0219 |

[a,b,c] Mean values having different superscript along were significantly (P<0.05) different.
SC: Soybean chaff, SEM: Standard Error of Mean.

table to the consumers. This is in agreement with the previous findings by Adeyemo and Sani (2013) who reported non-significant difference in the organoleptic properties of broiler chickens fed hydrolyzed cassava peel based diets. Adedeji *et al*. (2014) also reported no significant difference in sensory evaluation of organically raised broiler chickens. In addition, Tsado and Akinwolere (2015) also noted that feeding rumen filtrate fermented shea nut meal had no significance influence on the roasted and cooked broiler meat.

The best strategy to reduce cost of production and increase profit margin in livestock production is the development of diet formulation using alternative, locally available ingredients. The cost implication indices for this study (**Table VIII**) revealed that cost of feed (₦/kg) reduced significantly as the level of soybean chaff increases due to lower price of soybean chaff compared with wheat offal. The costs of diets were calculated using the prevailing current prices of the feed ingredients as at the time of the experiment. The cost economics was based on the assumption that labour and other overhead costs were similar for all dietary treatment hence they were excluded from the calculation. Lowest (P<0.05) cost of feed consumed observes in birds fed 50% SC could be attributed to reduced feed intake. Birds fed 100% soybean chaff had least (P<0.05) cost of feed, cost of feed per weight gain and most profitable commercial value as revealed by reduced total cost of production. Therefore, the use of Soybean chaff as replacement of wheat offal would be more profitable for the purpose of commercial broiler production.

## CONCLUSION

In summary, the study concluded that substitution of wheat offal with soybean chaff in the diets of broiler chickens resulted in reduced feed intake with similar body weight. Birds fed 100% soybean chaff had higher live weight, plucked weight and empty gizzard weight compared to other treatments. Replacement of wheat offal with soybean chaff did not interfere with the organoleptic properties of broiler meat. More so, birds fed 100% soybean chaff had least cost of feed, cost of feed per weight gain and most profitable commercial value as revealed by reduced total cost of production. Therefore, soybean chaff could be used to completely replace wheat offal as dietary fibre source in the diets of broiler chickens.

## CONFLICT OF INTEREST

The authors declare no conflicts of interest.

## BIBLIOGRAPHY

Adedeji, OS, Amao, SR, Oguntunde, MM & Dada, ID 2014, 'Evaluation of general performance and carcass qualities of organically raised broiler chickens from day old to 12 weeks of age', *International Journal of Agriculture Innovations and Research,* vol. 2, pp. 446-471.

Adeyemi, OA, Fashina, OE & Balogun, MO 2000, 'Utilization of full-fat Jatropha seed in broiler diet: effect on haematological parameters and blood chemistry', In 'Proceeding of the 25th Annual Conference of Nigeria Society for Animal Production (NSAP)', Abia State, Michael Okpara University of Agriculture, Umudike, pp. 108-109.

Adeyemo, IA & Sani, A 2013, 'Physical appearance and organoleptic properties of poultry meat fed *Aspergillus niger* hydrolyzed cassava peel meal based diet', *International Journal of Agricultural Policy and Research,* vol. 1, pp. 166-171.

Agbede, JO, Ajaja, K & Aletor, VA 2005, 'Response of broiler chicks to Roxazyme G supplemented diets in which wheat offal and rice bran replaced maize', *Applied Tropical Agriculture,* vol. 10, pp. 39-43.

Agboola, AF, Ajayi, HI, Ogunbode, SM, Majolagbe, OH, Adenekan, OO, Oguntuyo, CT & Opaleye, RO 2013, 'Serum biochemistry and haematological indices of broiler chickens fed graded levels of Frog (*Rana esculata*) meal as replacement to fish meal', *International Journal of Agriculture and Biosciences,* vol. 2, pp. 260-265.

Ali, MN, Abou Sekken, MS & Mostafa, KEME 2008, 'Incorporation of wheat bran in broiler diets', *International Journal of Poultry Science,* vol. 7, pp. 6-13.

AOAC 1990 'Official Methods of Analysis', Association of Official Analytical Chemists, 15th ed. Arlington, VA, USA.

Benerjee, GC 2008, 'Textbook of Animal Husbandry', New Delhi, Oxford and IBH publishing company, PVT. LTD.

Champ, M, Langkilde, A, Brouns, F, Kettlitz, B & Collet, Y 2003, 'Advances in dietary fibre characterisation. 1. Definition of dietary fibre, physiological relevance, health benefits and analytical aspects', *Nutrition Research Reviews,* vol. 16, pp. 71-82.

Donkoh, A, Nyannor, EKD, Asafu-Adjaye, A & Duah, J 2003, 'Ground maize cob as a dietary ingredient for broiler chickens in the tropics', *Journal of Animal and Feed Sciences,* vol. 12, pp. 153–161.

Fafiolu, AO, Otakoya, IO, Adeleye, OO, Egbeyale, LT, Alabi, JO & Idowu, OMO 2014, 'Comparing the blood profile of two strains of broiler chickens with varying interval of post hatch feeding', *Nigeria Journal of Poultry Science,* vol. 11, pp. 196-203.

Jimenez-Moreno, E, Gonzalez-Alvarado, JM, Lazaro, P & Mateos, GG 2009, 'Effects of type of cereal, heat processing of the cereal, and fiber inclusion in the diet on gizzard pH and nutrient utilization in broilers at different ages', *Poultry Science,* vol. 88, pp. 1925-1933.

Lawal, TE, Faniyi, GF, Alabi, OM, Ademola, SG & Lawal, TO 2012, 'Enhancement of the feeding value of wheat offal for broiler feeding after its solid state fermentation with *Aspergillus niger*', *African Journal of Biotechnology,* vol. 11, pp. 12925-12929.

Liu, YG & Baidoo, SK 2005, 'Exogenous enzymes for Pigs diets: An Overview', In 'Proceedings of the 2005 Asian Conference on Feed Biotechnology', pp. 67-70.

Marston, TT, Lusby, KS & Wettemann, RP 1993, 'Effects of different supplements and limited-dry lot feeding on replacement heifer development', *Oklahoma State University Animal Science Research Repository* MP-933, p. 100

Mateos, GG, Jimenez-Moreno, E, Serrano, MP & Lazaro, P 2012, 'Poultry response to high levels of dietary fiber sources varying in physical and chemical characteristics', *Journal of Applied Poultry Research,* vol. 21, pp. 159-174.

NRC 1994, 'Nutrient Requirements of Poultry' National Research Council, 9th ed. USA, Washington DC, National Academy Press.

Oke, FO, Fafiolu, AO, Jegede, AV, Oduguwa, OO, Adeoye, SA, Olorunisola, RA, Oso, AO, Onasanya, GO, Adedire, AO & Muhammed, AI 2015, 'Performance and nutrient utilization of broilers fed malted sorghum sprout (MSP) or wheat-offal based diets supplemented with yeast culture and enzyme', *Online Journal of Animal and Feed Research,* vol. 5, pp. 78-84.

Sarikhan, M, Shahryar, HA, Gholizadeh, B, Hosseinzadeh, MH, Beheshti, B & Mahmoodnejad, A 2010, 'Effects of insoluble fiber on growth performance, carcass traits and ileum morphological parameters on broiler chick males', *International Journal of Agricultural Biology,* vol. 12, pp. 531-536.

SAS 2007, 'Statistical Analysis System for Windows, 9.1.3 portable version. USA, North Carolina, SAS Institute Inc.

Sruamsiri, S & Silman, P 2008, 'Nutritive composition of soybean by-products and nutrient digestibility of soybean pod husk', *Maejo International Journal of Science and Technology,* vol. 2, pp. 568-576.

Stone, H & Sidel, JL 2004, 'Sensory Evaluation Practices. 3rd edition'. A Volume in Food Science and Technology, USA, California, Academic Press Inc.

Svihus, B, Juvik, E, Hetland, H & Krogdahl, A 2004, 'Causes for improvement in nutritive value of broiler chicken diets with whole wheat instead of ground wheat', *British Poultry Science,* vol. 5, pp. 55-60.

Tsado, DN & Akinwolere, J 2015, 'Performance and organoleptic properties of broilers fed replacement levels of rumen filtrate fermented shea nut (*Vitellaria paradoxa*) meal for groundnut meal', *Net Journal of Agricultural Science,* vol. 5, pp. 86-92.

Weiss, DJ & Wardrop, KJ 2010, 'Hematology of Chickens and Turkeys', In 'Schalm's Veterinary Hematology', 6th ed. pp. 958-967. USA, Wiley-Blackwell Publisher, A John Wiley and Sons Ltd Publication.

Wofford, PD, Essig, HW, Boykin, KP & Cantrell, CE 1994, 'Soybean hulls and soybean oil in wintering diets of replacement heifers', *Journal of Animal Science,* vol. 5, pp. 9. (Abstr.).