EFFECT OF DIFFERENT LEVELS OF DIETARY COTTONSEED OIL ON BROILER CHICKS PRODUCTION

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ABSTRACT: **This study was conducted to evaluate the effect of dietary cottonseed oil (CSO) at different levels on broiler chickens. Dietary CSO was tested for energy supplementation values in poultry at levels 0, 3, 6 and 9% utilizing isonitrogenous (22.5% CP), semi-isocaloric (3100 Kcal/kg) rations and run in the experiment. Ninety-six seven-day old unsexed Ross-308 broiler chicks with an initial weight of 72.9 g were used for each experiment in a completely randomized design (4x4x6). Chicks were fed for 42 days. Supplementation with the oils improved performance ($p>0.05$) but CSO gave significant ($p<0.05$) values in final, weight gain and feed conversion ratio. Results of energy retention showed similar values in initial energy, but final and gained energy revealed significant ($p<0.05$) differences among treatment groups. Feed intake, weight gain and final weights of birds were significantly reduced ($p<0.05$) across treatments by the increased dietary inclusion of CSO while feed conversion ratio of birds increased significantly with increasing dietary CSO ($P<0.05$). Also, hematological values, serum metabolites, enzyme activities and electrolytes, the packed cell volume (PCV), hemoglobin (Hb) and white blood cell (WBC) varied significantly ($P<0.05$) with inclusion. Adding 3-6% of the oil improves the carcass, the feed intake, feed conversion efficiency, and the profitability margin.**

KEYWORDS: *Broiler; Cottonseed; Dietary fat; Economic profile; Metabolizable energy.*

1. INTRODUCTION

Cottonseed oil (CSO) is derived from the seeds of the cotton plant (*Gossypium* sp). CSO is used almost entirely in the production of edible products. Food uses of vegetable oils can be divided into the categories of liquid or cooking oils, salad oils, margarine, shortening and other products (Frank, 2011). Like all vegetable oils, CSO is composed principally of triacylglycerols. Linoleic, oleic, and palmitic acids make up the bulk of the observed free fatty acids in crude CSO, (Wan *et al*., 2007). It has also been reported as a component of cottonseed oil's fatty acid profile at a level of about 0.2%, (Fisher & Cherry, 1983), stearic and oleic, (Ahmad *et al*., 2007), phospholipids, (Cherry, 1985). About 80% of the sterols are free (non-esterified) form, (Verleyen *et al*., 2002). The total level of tocopherols in crude cottonseed oil is of the order of 900–1,000 ppm, (List and Friedrich 1989; O'Brien *et al*. 2005), known to contain significant levels of sucrose, raffinose, and stachyose. These compounds make up about 11% of the weight of defatted cottonseed, (Kuo *et al*., 1988). The main carotenoid found is lutein, with smaller amounts of isolutein, neoxanthin, violaxanthin, α- and β-carotene, and other xanthophylls, (Thompson *et al*., 1968), squalene has been reported by Bailey (1948). The concentration of gossypol in glanded cottonseed was ranged between 0.8% and 1.5%, although levels between 3% and 4% are not unusual, (Percy *et al*., 1996). Gossypol which is a toxic or anti-nutritional dye, it causes iron deficiency and lysine unavailability due to Millard reactions, thus reducing the nutritional value of proteins, (Baião and Lara, 2005). Characterization of vegetable oils can be divided into tests that determine the physical, chemical, and optical properties of the oil. Some properties relate directly to the composition of the triacylglycerol fatty acids; other properties are affected by the order of the fatty acid along the glycerol backbone and the relative levels of the various triacylglycerol molecules present in the oil. Three basic habits have been identified: α-, β2- and β-forms. The α-crystal habit is metastable and tends to slowly reorganize into the β2-form vegetable oils crystallize into the β-form, (O'Brien *et al*. 2005). CSO is classified as an 'oleic-linoleic'-type vegetable oil, in that these acids make up most of the fatty acid composition of the oil. Roughly half of the fatty acids are linoleic acid and 16–20% is oleic acid. Together with palmitic acid, these three fatty acids account for around 91% – 93% of the fatty acids in CSO, Stearic acid at between 2% and 3%. Several minor fatty acids are also present in the oil (these include myristic, palmitoleic, malvalic, cis-vaccenic, sterculic, α-linolenic, arachidic, behenic, and lignoceric acids), (Badami & Patil, 1981). Fats can be incorporated in the diet for two purposes, to boost the energy content of a diet already high in energy and thus to obtain an enhanced growth rate, or to permit the use of a food which is cheaper but lower in energy to replace one rich in energy, (Bolton *et al*., 1959). The objective of the present experiment was to study the effect of CSO that was tested for energy supplementation values in poultry to dietary with different levels of the approximate requirement in a common feeding regimen for broilers reared to compare responses to those receiving the level at the same crude protein (CP) and metabolizable energy (ME).

2. MATERIALS AND METHODS

2.1 Birds and Housing

A number of ninety-six, seven-day-old commercial broilers Ross-308 were

obtained from Arab Poultry Breeder Company (Ommat "Mothers") and transported to Student Poultry Premises, Faculty of Agricultural Studies, Sudan University of Sciences and Technology, Shambat. Each weighing between 72.9 g approximately placed randomly in (3 ft × 4 ft) floor pens at a density of approximately 0.305 m^2 (1.0 ft^2) of available floor space per broiler; new pine shavings with a minimal amount of sawdust was provided as litter. Pens were separated by a wire partition and did not touch other pens from any side to minimize the potential for cross-contamination. A continuous 24-hrs lighting program was followed. Birds were observed 3 times daily for overall health, behavior and evidence of toxicity, and environmental conditions. No type of medication was administered during the entire feeding period. Mortalities were recorded, drinking water was provided for *ad libitum* consumption fed in one phase (7^{th} to 42^{nd} day) to minimize the possibility of cross-contamination between diets was offered as a mash. The experimental was a completely randomized design with 4 dietary treatments (control, and 3 commercial references). 6 broilers per pen and 4 pens (4 replicates). Diet was formulated to the same ME level 3,100 kcal of ME/kg. Tables 1, show the composition of diets. The feeds were subjected to analysis for crude protein (N x 6.25) and found to be in agreement with the calculated values feed analyses according to the Association of Official Analytical Chemists (AOAC), (AOAC, 2003).

2.2 Data Collected on Performance

Data on average body weight, weight gain and feed consumption (g) for each group were determined weekly throughout the experimental period. The health of the experimental stock and mortalities were closely and carefully observed.

2.3 Chemical Methods

Feed analyses according to the Association of Official Analytical Chemists (AOAC), (AOAC, 2003). Meat cholesterol was determined according to Bergmeyer and Bernt (1974).

2.4 Serum Determinations

Determination of total cholesterol was done following the method established by Allain *et al.*, (1974), alkaline phosphatase was determined according to Bowers and Mc Comb (1966). Glucose serum was measured according to the method described by Hanssen *et al.*, (1992). Total serum protein was measured according to Ross *et al*., (1978). Urea serum concentration was estimated according to Tietz (1976). Hematocrit or Packed Cell Volume % (PCV%), haemoglobin (Hb)%, red blood cells (RBC) and white blood cells (WBC) were also determined using traditional methods (Dein, 1984; Albokhadaim, 2012) to see the effect of feeding cottonseed oil on their level in the blood serum. The serum electrolytes and enzymes such as alanine aminotransferase (ALP) and aspartate aminotransferase (AST) values were determined to check the effect of the treatment and calcium serum concentration was also determined according to Fujita (2006). Fatty acids composition was determined using the official methods of the AOCS (2000). Phosphorus determined using the suitable method of the official method of the AOAC (2003).

2.5 Determination of Oils Contents

The fatty acid composition was determined according to AOCS (2000). The viscosity of the oil samples was recorded according to Cocks and Van Rede (1966). Peroxide value (PV) and the Free Fatty

Acids % (FFA %) were determined according to the AOAC (2003).

2.6 Slaughtering and Processing

At the end of the 6th week, the birds fasted overnight with only water allowed before terminally slaughtered. Birds were weighed individually before slaughter according to Mohammed (1996) the left side was divided into three commercial cuts, thigh, drumstick and breast, each cut was weighed separately. The breast, drumstick and thigh cuts of the right side were skinned and deboned, the meat and bone were weighed separately, and the meat was frozen and stored for further analysis.

2.7 Statistical Analysis

Statistical examination of the data was performed using the analysis of variance, which proposed by Snedecor and Cochran (1980), the means of three replicates were compared using least significant difference (LSD) procedure as outlined by Steel and Torrie (1980).

The experimental diet fed to broiler chicks is shown in Table 1, which shows the percent inclusion rates (as fed basis) and calculated analyses based on dry-matter of the experimental diets used in the experiment for 42 days.

Table 1: Percent inclusion rates (as fed basis) and calculated analyses (dry-matter basis) of experimental diets fed to broiler chicks for 42 days.

Items	**Ingredients**			
	Ration (1)%	**Ration (2)%**	**Ration (3)%**	**Ration (4)%**
Sorghum (Feterita)	54.00	51.00	48.00	45.00
Groundnut cake	15.00	15.00	15.00	15.00
Sesame cake	14.00	14.00	14.00	14.00
Wheat Bran	10.00	10.00	10.00	10.00
Cottonseed oil	00.00	03.00	06.00	09.00
Salt	00.50	00.50	00.50	00.50
*Concentrate	05.00	05.00	05.00	05.00
Limestone	01.50	01.50	01.50	01.50
Total	100	100	100	100
Calculated analysis				
Dry matter	96.38	96.22	95.91	95.66
Crude protein	22.50	22.40	22.50	22.60
Ether extract	02.10	04.20	07.50	10.30
Crude fiber	11.20	12.50	11.80	10.70
N-free extract	54.88	54.12	53.91	55.26
Ash	04.40	04.00	04.20	03.80
ME, Mcal/Kg	02.04	03.10	04.15	05.19

*crude protein: 40.00; crude fat: 4.00; crude fiber: 2.00; Calcium: 4.00; Phosphorus (avail): 4.00; Lysine: 12.00; Methionine: 3.00; Meth+Cyst: 3.20; Met. Energy: 2100Kcal/Kg; Sodium: 2.60; product: vit. A: 200.000 I.U/Kg; vit. D3: 40.000 I.U/Kg; vit. E: 500mg/Kg; vit. B1: 15mg/Kg; vit.B2: 100mg/kg; vit.B6:20; vit. B12: 300mcg/Kg; Biotin: 1.000mcg/Kg; Nicotinic acid: 600mg/Kg; Folic acid: 10mg/Kg; vit. K3: 30 mg/Kg; pantothenic acid: 150 mg/Kg; choline chloride: 5.000 mg/Kg; copper: 100 mg/Kg; iodine: 15 mg/Kg; Cobalt: 3 mg/Kg; selenium: 2 mg/Kg; manganese: 1.200mg; zinc: 800 mg/Kg; iron: 1.000 mg/Kg; BHT: 900 mg/Kg; Salinomycin-Na: 1.200.

Table 2: Analysis of variance and average (mean ± SD) performance values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† -value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Final weight	02.30*	2327.60^{a} ± 41.90	2370.90^{a} ± 133.60	2475.90^{a} ± 141.90	2052.50^{b} ± 229.70
Weight gain	05.90*	2253.02^{a} ± 40.00	2294.30^{a} ± 134.30	2403.60^{a} ± 145.60	1970.20^{b} ± 227.50
Daily feed intake	01.30^{NS}	90.93 ± 06.98	100.64 ± 10.40	93.10 ± 05.27	90.20 ± 09.86
Daily energy intake (kcal/g)	01.28^{NS}	276.42 ± 21.21	311.98 ± 32.27	293.31 ± 16.59	287.76 ± 31.47
Feed conversion ratio	04.80*	02.03^{b} ± 00.20	02.20^{ab} ± 00.14	02.00^{b} ± 00.10	02.30^{a} ± 00.20
Mortality %	00.44^{NS}	04.20 ± 0.35	03.33 ± 0.65	04.20 ± 0.35	00.00 ± 00.00

†At (3, 12) d.f. Means in a row bearing the same letter or no letter superscript do not differ significantly ($p>0.05$).
NS = not significantly different ($p>0.05$).

Table 3: Analysis of variance and average (mean ± SD) hematological values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Hematocrit (Packed Cell Volume) PCV%	00.50NS	22.70 ± 03.20	23.70 ± 01.20	24.70 ± 01.90	23.80 ± 00.90
Hemoglobin (Hb%)	00.60NS	08.90 ± 01.70	09.30 ± 01.10	10.20 ± 01.40	09.40 ± 00.60
Red Blood Cells (RBC) ($\times 10^{6}$)	00.20NS	02.30 ± 00.40	02.10 ± 00.20	02.10 ± 00.60	02.00 ± 00.40
White Blood Cells (WBC) ($\times 10^{3}$)	00.60NS	07.58 ± 01.37	07.24 ± 00.64	06.79 ± 00.55	07.70 ± 01.00

†At (3, 12) d.f. NS = not significantly different ($p>0.05$). Means in a row do not differ significantly ($p>0.05$).

Table 4: Analysis of variance and average (mean ± SD) serum metabolites values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Cholesterol(mg/dl)	00.20NS	141.80 ± 12.50	147.20 ± 18.10	145.70 ± 09.80	137.40 ± 19.40
Glucose (mg/dl)	00.10NS	192.90 ± 59.80	210.40 ± 87.20	215.00 ± 52.60	239.20 ± 72.30
Total protein(g/dl)	00.10NS	003.20 ± 00.80	003.20 ± 00.90	03.00 ± 00.60	03.30 ± 00.90
Urea (mg/dl)	01.90NS	014.30 ± 05.00	010.70 ± 01.20	16.10 ± 03.50	16.70 ± 02.70

†At (3, 12) d.f.
NS = not significantly different ($p>0.05$). Means in a row are similar ($p>0.05$).

3. RESULTS AND DISCUSSION

3.1 Response of broiler chicks to dietary cottonseed oil performance

The effect of feeding different levels of dietary cottonseed oil on performance of broiler chicks is shown in Table 2. Initially, all groups started and finished at similar ($p>0.05$) body weights, treatment effect significant ($p<0.05$). Mean values of final weight, weight gain and feed conversion ratio were similar ($p<0.05$) except group D. Daily feed intake and daily energy intake (kcal/g) not significant ($p>0.05$) When birds are fed diets that have been freed from fat the death rate is high. The addition of fat to broiler dietary a conversion ratio of live weight increase was obtained as was also reported by Bolton *et al*., (1959).

Mean values of both daily feed and energy intake are highest ($p>0.05$) in group B that reflected on weight gain. Group C recorded best feed conversion ratio, mortality not significant ($p>0.05$) similar in all groups within the economically permissible limits, therefore the supplemented diet with CSO food consumption is increased in total bulk; with a concomitant increase in growth rate, and hence an increase in efficiency of food conversion and a reduction in the time taken to reach market weight beyond what could be expected from the increase in food value. This in line by earlier reports of Hill & Dansky 1954; Sklan, 1979; Corino *et al*., 1980; Leeson & Atteh, 1995 observed that the most practical method for increasing the energy density of diets is through the addition of fats and oils. Birds adjust their feed intake to achieve the daily energy intake, (Renner & Hill, 1961) the primary factor affecting the ME value of fat is its digestibility. The digestibility of fats is dependent on factors such as length of the carbon chain and the degree of saturation of the fatty acids.

The hematological indices of broiler birds are presented in Table 3. There were no significant variations ($P>0.05$) in the values of PCV, Hb and WBC among dietary treatments, or such changes could be accounted for by altered food intake. The PCV level is one of the indicators suggestive of the presence of a toxic factor that adversely affects blood formation, (Mitruka & Rawsley, 1977). The PCV values obtained from this study were within the standard range of 22-35%, (Schalm *et al*., 1975) for healthy chickens, in this study, the values obtained for WBC of birds were within the reference range of 9 - $31x10^3/mm^3$, (Reitman & Franke, 1957) for healthy birds. Decreased WBC below the normal range is an indication of allergic conditions, anaphylactic shock and specific parasitism or presence of foreign body in circulating system, (Schalm *et al.*, 1975; Mitruka & Rawsley, 1977) Red blood cell values obtained in this study did not significantly ($P>0.05$). This showed that graded dietary CSO had no influence on RBC of birds and it revealed that the birds were not anemic.

3.2 Serum metabolites

The serum metabolites values are shown in Table 4. Treatment effect in all serum metabolites showed no significant ($p>0.05$) difference.

Mean values of total cholesterol present a similar pattern of variation as a function of addition of oil, with higher values in B and C birds, due to the absence of superficial fat in meat samples, or due to the bird's high energy requirement as observed in other studies by Ross *et al*., (1976); Rowe *et al*., (1997) and Oguz *et al.*, (2002). The higher values of these components in these groups correspond to their low mobilization by tissues and to their great synthesis. The evaluation of total protein serum levels did not reveal any differences in all groups. These data are compatible with those presented above for uric acid level, the main catabolite of protein metabolism, which presented the highest serum levels. Glucose is utilized by birds for a variety of functions, particularly for energy production through cellular oxidation, glycogen synthesis in the liver and glycolytic muscles, fatty acid synthesis as well as synthesis of nonessential amino acids, vitamin C, and other metabolites. This in line with Umminnger, 1975, Pollock, 2002; Braun & Sweazea, 2008, plasma glucose concentrations in bird species is 150 t; 300% higher than in mammals of similar body mass. Besides Gibson *et al.*, (1989) reported that domestic fowl are known for their insulin resistance, because massive doses of insulin, which would be lethal to mammals, do not cause hypoglycemic convulsions in chickens.

3.3 Serum electrolytes and enzyme activities

The serum electrolytes and enzymes values are shown in Table 5. Treatment effect in serum electrolytes and enzymes were not significant ($p>0.05$). Mean values of alanine aminotransferase (ALP) and aspartate aminotransferase (AST) activities are highest in group C. Mean values of calcium and inorganic phosphorus are highest ($p>0.05$) in group C. Inorganic phosphorus is critical for numerous standard physiologic functions including skeletal development, mineral metabolism, energy transfer through mitochondrial metabolism, cell membrane phospholipid content and function, cell signaling, and even platelet aggregation. Abnormalities of calcium and phosphorus homeostasis are common and collectively are called disorders of mineral metabolism. Normal homeostatic regulation maintains serum levels, intracellular levels, and optimal mineral content in bone. This regulation occurs at three major target organs, the intestine, kidney and bone, principally via the complex integration of two hormones, parathyroid hormone and vitamin D, (Ghosh & Joshi, 2008). Serum calcium levels are tightly controlled within a narrow range, usually 8.5–10.5 mg/dL (2.1–2.6 mmol/L). However, the serum calcium level is a poor reflection of overall total body calcium, as serum levels are 0.1–0.2% of extracellular calcium, which in turn is only 1% of total body calcium. Because of its importance, normal homeostasis maintains serum concentrations between 2.5 to 4.5 mg/dl (0.81 to 1.45mmol/L), (Sharon, 2008). Guerreiro *et al.,* (2011) who did not find any blood parameters differences between broilers fed vegetable oils. However, results of some studies do not agree with the findings of the present experiment. Monfaredi *et al*., (2011) reported that serum glucose and cholesterol were affected by the use of soybean oil in broiler chickens.

Table 5 shows the means and standard deviations of mineral serum levels. There were changes in the levels of Calcium with the highest values obtained in the control group. Phosphorus level was similar to those observed in the control group in the study of Oguz *et al.*, (2000). There is a relationship between the parathyroid gland

and the secretion of calcium in the bones or increase renal calcium re-absorption Sharon, (2008). A similar inverse relation between Ca content of the diet and plasma alkaline phosphatase values were observed as was reported by Hurwitz and Griminger, (1961). Serum alkaline phosphatase was found to be consistently higher in most cases between 2 and 6 weeks of age in a line bred for high alkaline phosphatase. The level of the male was higher than the female during the growing period, but lower at later ages. There were no differences due to line or sex at hatching as was also reported by Yuichi and Wilcox, (1960). The enzymes aspartate aminotransferase (AST) and alanine aminotransferase (ALP) are used to indicate liver function status, the biochemical analysis showed no significant ($p>0.05$) increase in the activities of ALP, AST enzymes and an elevation in the values of uric acid and creatinine with a reduction in the total serum protein. An elevation in the hepatic enzyme activities in the group could reflect the hepatic damage and leakage of enzymes in the bloodstream.

3.4 Slaughter values

The slaughter values are shown in Table 6. The treatment effect in slaughter values is not significant except for the heart and liver ($p<0.05$).

Mean values of slaughter weight, empty body weight, hot carcass weight, heart and liver recorded highest no significant ($p<0.05$) values in group C. Mean values of gizzard showed the highest value in group B, whilst intestine and abdominal fat means are the highest in group D. the use of good quality biological material, breeder companies were concentrated on developing new commercial hybrids of meat chicken with superior performances, sex, age, and environmental conditions influence the slaughter yield of broiler chickens, yields of the cut parts from carcass, the muscles weight and poultry meat quality. These results are in line with those obtained by Marcu *et al*., (2014) that the nutrition and age had a significant influence on the slaughter yield, the participation percentage of the cut parts from the whole carcass and meat/bones ratio in breast and legs. Earlier reported by Adams *et al., (*1994) found that feeding diets based on high oil corn had no adverse effect on dressing percentage, abdominal fat content, or weight loss during cooking.

3.5 Carcass yield

The carcass cuts and tissue weight values are shown in Table 7. The results showed treatment effect significant ($p<0.05$) in drum cut and drum muscle. There is no significant ($p>0.05$) difference between groups in mean cuts weights or tissues, which recorded highest values in group C, except the mean value of breastbone which was highest in group B.

Treatments effect is not significant ($p>0.05$) in all carcass cuts and tissue percentages. Mean values of thigh, thigh bone, thigh muscle, breast and breast muscle showed highest ($p>0.05$) values in group C. Mean values of drum and drum muscle recorded highest ($p>0.05$) values in group C. Mean values of breast and drum bone showed highest ($p>0.05$) values in groups B and D respectively. Özdogan1 and Aksit (2003) reported on the effect of fat sources in the feed on the moisture, ash, and fat content of thigh and breast of broilers. Song *et al.*, (2004) indicated that bird type has a significant effect on results and should be considered when developing true amino acid availability.

Table 5: Analysis of variance and average (mean ± SD) serum enzymes and electrolytes values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Calcium (mg/dl)	00.30NS	09.40 ± 01.60	08.80 ± 01.04	08.30 ± 01.90	7.90 ± 02.70
Phosphorus(mg/dl)	00.20NS	01.20 ± 00.50	01.40 ± 00.40	01.30 ± 00.20	01.30 ± 00.20
ALP (IU/l)	00.40NS	180.20 ± 61.80	205.10 ± 89.90	299.40 ± 82.50	198.80 ± 13.00
AST (IU/l)	01.00NS	18.30 ± 02.30	22.40 ± 04.50	24.60 ± 07.90	19.30 ± 03.40

†At (3, 12) d.f. Means in a row do not differ significantly (p>0.05).
NS = not significantly different (p>0.05).

Table 6: Analysis of variance and average (mean ± SD) slaughter values (g) of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Slaughter weight	02.58NS	2155.00 ± 214.10	2147.50 ± 345.02	2568.80 ± 231.60	2185.00 ± 196.70
Empty body weight	02.58 NS	2141.28 ± 214.94	2132.65 ± 344.88	2553.73 ± 231.27	2169.20 ± 195.92
Hot carcass weight	02.40NS	1649.60 ± 257.90	1688.10 ± 289.00	2031.00 ± 180.30	1676.70 ± 177.60
Heart	08.30*	16.60_{b} ± 01.90	15.60^{b} ± 01.50	22.80^{a} ± 03.50	18.20^{b} ± 01.02
Liver	18.50*	40.00_{b} ± 04.10	35.00^{b} ± 04.10	53.80^{a} ± 04.80	40.00^{b} ± 00.00
Gizzard	00.30NS	40.00 ± 04.10	42.50 ± 13.20	38.80 ± 04.80	37.50 ± 02.90
Intestine	01.96 NS	77.53 ± 06.40	83.90 ± 04.07	84.98 ± 06.03	89.20 ± 09.82
Abdominal fat	01.20NS	31.30 ± 10.30	20.00 ± 16.80	36.30 ± 18.00	41.30 ± 20.20

†At (3, 12) d.f. Means in a row bearing the same letter or no letter superscript do not differ significantly (p>0.05).
NS = not significantly different (p>0.05).
* Denotes f-value significant at p<0.05.

Table 7: Analysis of variance and average (mean ± SD) carcass cuts and tissue values (g) of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Thigh	02.02NS	255.00±33.20	245.00±49.30	295.00±40.40	235.00±17.30
Thigh bone	01.60NS	42.50±05.00	42.50±09.60	47.50±05.00	37.50±05.00
Thigh muscle	01.70NS	212.50±33.00	202.50±40.30	247.50±42.70	197.50±15.00
Drum	07.20*	205.00b±17.30	207.50b±26.30	260.00a±21.60	205.00b±12.90
Drum bone	00.90NS	55.00±12.90	60.00±00.00	67.50±17.10	62.50±05.00
Drum muscle	06.00*	150.00b±08.20	145.00b±23.80	192.50a±25.00	142.50b±15.00
Breast	00.20NS	487.50±108.70	477.50±129.70	530.00±101.00	482.50±76.30
Breast bone	01.40NS	60.00±21.60	87.50±12.60	77.50±22.20	77.50±20.60
Breast muscle	00.30NS	427.50±92.50	390.00±135.90	452.50±83.40	405.00±83.50

†At (3, 12) d.f. Means in a row bearing the same letter or no letter superscript do not differ significantly (p>0.05).
NS = not significantly different (p>0.05).
* Denotes f-value significant at p<0.05.

3.6 Meat quality attributes

The percent meat chemical values are shown in Table 8. Treatment effect in all meat chemical components assayed is not significant (p>0.05).

Mean values of moisture recorded higher (p>0.05) values in group C. Mean values of

crude protein (CP) and ash gave highest ($p>0.05$) values in group B The relationship between broiler breast meat color and pH, moisture content, water-holding capacity (WHC) had significant correlations with moisture, (Qiao *et al*., 2001). Mean values of ether extract (EE) and cholesterol gave highest values in group D. Cholesterol in this study agrees with the typical values reported by Sturkie *et al.,* (2000) 100-150 mg/dl. They noted a consequent increase in the cholesterol level of the blood when feed cholesterol intake was increased. The values of cholesterol reported by Aderemi, (2004) (100.3-108.21 mg/dl) and Nworgu, (2004) (93.33-116.67 mg/dl) were lower than those reported in this study. Variations in cholesterol could be attributed to breed of chicken, nutritional pattern, type of feed and environmental factors, (Nworgu *et al.,* 2007), these results indicate that vast differences in raw breast meat color exist and that further poultry processors may use these differences as an indicator of fillets with altered functional properties, (Qiao *et al*., 2001).

The percent meat individual values of broiler chicks fed different levels of cottonseed oil for 42 days are shown in Table 9.

Treatment effects in sensory values showed non-significant ($p>0.05$) differences between groups. Mean values of all sensory attributes are closely similar ($p>0.05$). Eltazi, (2000) in a panel test, agreed to significant differences in tenderness and juiciness when feeding broilers corn oil at 2, 4 and 6%. The deposition of inter and intramuscular fat with other intracellular components in broiler carcasses would bring differences in organoleptic values, (Lawrie, 1979). According to Grashorn (1995), the most important criteria for meat quality are juiciness and tenderness. These two attributes are closely related, for more tender meat, juices are released more quickly on chewing, and the wet sensation of the meat is greater. The appraisal of major inputs and margin over significant inputs per head is shown in Table 10.

Chick purchase and feed cost values (SDG) were the significant inputs considered. The total selling values of meat are the total income obtained. Profitability ratio (01.39) of group C (6% cottonseed oil) was the highest of the test. This result was in line with many researchers such as Adams *et al.,* (1994) mentioning economic considerations of high oil corn should include its potential to improved performance. Also, Saleh *et al.,* (1997) improved live weight gain and reduced feed conversion ratios concomitant with increased nutrient density. While Lopez-Ferrer *et al.,* (2001) improved meat quality parameters of the chick breast, no differences between treatments or sexes were detected.

4. CONCLUSION

It could be concluded that supplementation of broiler chicks fed with cottonseed oil (CSO) improved performance and resulted in significant values ($p<0.05$) in the final, weight of birds and feed conversion. Feed intake, weight gain and final weights of birds were significantly reduced ($p<0.05$) across treatments by the increased dietary inclusion of CSO while feed conversion ratio of birds increased significantly with increasing dietary CSO ($P<0.05$). Also, hematological values, serum metabolites, enzyme activities and electrolytes, the packed cell volume (PCV), hemoglobin (Hb) and white blood cell (WBC) varied significantly ($P<0.05$). Adding 6% of the oil improves the carcass,

Table 8: Analysis of variance and average (mean ± SD) of percent meat chemical values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Moisture	00.90NS	69.80 ± 03.20	68.70 ± 01.70	71.30 ± 00.80	68.60 ± 03.80
Crude Protein (CP)	00.90NS	19.90 ± 01.80	20.30 ± 01.30	18.70 ± 00.90	19.90 ± 01.70
Ether Extract (EE)	00.50NS	06.40 ± 03.10	07.60 ± 00.80	06.70 ± 00.60	07.70 ± 02.10
Ash	00.40NS	00.70 ± 00.40	01.00 ± 00.30	00.70 ± 00.50	00.80 ± 00.50
Cholesterol (mg)	00.70NS	07.83 ± 01.86	06.63 ± 01.58	08.98 ± 02.26	10.38 ± 06.84

†At (3, 12) d. f. Means in a row do not differ significantly (p>0.05).
NS = not significantly different (p>0.05).

Table 9: Analysis of variance and average (mean ± SD) of percent meat subjective values of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**F† - value**	**cottonseed oil levels**			
		A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Tenderness	02.30NS	05.70±00.30	04.40±01.10	05.50±00.60	05.00±00.80
Flavor	00.20NS	05.30±00.20	05.20±00.50	05.30±00.80	05.50±00.60
Color	01.50NS	05.50±00.50	04.50±00.50	05.50±01.10	04.80±01.00
Juiciness	01.00NS	05.30±00.10	04.20±01.05	04.90±01.10	04.50±01.00

†At (3, 12) d.f.
NS = not significantly different (p>0.05).
Means in a row do not differ significantly (p>0.05).

Table 10: Major inputs and margin over significant inputs per head of broiler chicks fed different levels of cottonseed oil for 42 days.

Items	**cottonseed oil levels**			
	A (0%)	**B (3%)**	**C (6%)**	**D (9%)**
Meat sales (SDG)*	11.50	11.80	14.20	11.70
Chick purchase (SDG)	02.250	02.250	02.250	02.250
Feed cost (SDG)**	03.10	03.80	03.90	04.10
A major cost of production	07.45	07.15	07.25	08.45
Margin over major inputs	04.05	04.65	06.95	03.25
Profitability (%)	35.20	39.40	48.90	27.80
Profitability ratio	01.00	01.10	01.39	00.79

the feed intake, feed conversion efficiency, and the profit margin as well. However, the study did not include the differences between other treatments or sexes of the experimental groups.

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