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Effects of Substitution of the Imported Super Concentrate with Graded Levels of Marula (*Sclerocarya birrea*) Kernel Meal on Growth Performance and Meat Quality of Broiler Chicks

Chou MI[1], Fadlelmola SAG[1], Teya SHK[2], Jadalla JB[1]* and Dahia SBH[3]

[1]Department of Animal Production, University of Kordofan, Sudan
[2]Department of Food Science and Technology, University of Kordofan, Sudan
[3]Department of Animal Production, University of Dallanj, Sudan

***Corresponding author:** Jumaa Barram Jadalla, Department of Animal Production, Faculty of Natural Resources and Environmental Studies, University of Kordofan, Sudan, Email: jumaaaringola2000@gmail.com

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Abstract

This study was conducted in Dilling town, South Kordofan State, Sudan with the objective of studying and evaluating the effects of using graded levels of Marula, *Sclerocarya birrea*, kernel meal on broilers Growth performance and meat quality. Two hundred, one day old (Ross 308) chicks were distributed into five groups of treatments where every 20 birds were housed in separate unit assigned to the five treatments A, B, C, D and E with four replicates, on floor covered with saw dust. The chicks were transferred periodically to ensure random housing. Starter and finisher rations were formulated for each treatment. The experimental diets were formulated with five levels of *Sclerocarya birrea* of (2.5%), (5%), (7.5%) and 10% as a substitute for the protein super concentrate. At the end of the experiment, twenty five chickens were slaughtered for carcass cuts yield and meat quality evaluation. The results indicated that feed intake was significantly ($P<0.01$) higher in birds on ration C compared to those on rations A, B, D and E. Similarly the live weight of chickens was significantly ($P<0.01$) heaviest in group C than those of groups A, B,D and E. Dressing percentage, carcass weight and weight of cuts were also significantly ($P<0.01$) higher for birds on ration C and lowest weight was recorded for those on ration E. Also the abdominal fat weight was higher for groups D and E with significantly differences ($P<0.01$) when compared with groups A, B and C. It was the lowest for chickens fed ration C. The percentage of fat in the body was higher in meat samples obtained from birds on rations D and E and lower for those on rations A, B and C. The study concluded that feeding *Sclerocarya birrea* kernel meal to broiler chicks improved feed intake, the rate of live weight gain though it increased the proportion of body fat in carcass samples when the level increased above 5%. It was recommended further studies be conducted using lower levels of *Sclerocarya birrea* kernel cake after oil extraction since it is found abundantly, can be obtained at low cost and rich in essential amino acids and fatty acids as well.

Keywords: Broiler Rations; Alternative Feed Resources; *Sclerocarya birrea* Meal

Abbreviation: DMRT: Duncan Multiple Range Test; CRD: Complete Randomized Design.

Introduction

Poultry is kept under different production patterns to provide high quality protein sources in Sudan. Evidence has shown that chickens provide rural households with scarce animal protein (meat and eggs) and being a reliable source of petty cash. Moreover, chickens are used for traditional ceremonies and festivals in some cultures. It is asserted that intake of quality animal protein provides good health and strengthens manpower needed to alleviate poverty and ensure food and nutritional security for socio-economic development of rural households [1]. The basic features of this type of production is the lower cost of care and feeding as a secondary activity adopted feeding small herds of chickens on the municipal agricultural waste and food scraps at home. Semi intensive production patterns have emerged in the peri-urban areas to meet the growing demand of eggs and meat. Family poultry production units are also growing at increasing level so rapidly. Governmental and commercial services such as provision of vaccines, drugs and supplements have assisted in introduction of modern systems of poultry production, especially provision of veterinary services, feed manufacturing and extension services in the field of management [2]. Although the continuous development of research in feed industry and poultry production grew enormously Idris AA [3], but it was faced by many constraints, mostly associated with feeding. Perhaps this is the single cost that makes up about 70-75 % of the total production costs. To sustain high levels of production, imported concentrates and mixture of multi vitamins were necessary. Those inputs are obtained at high cost. Some feed ingredients are competed for between poultry and humans. Locally available feed ingredients that are observed being ingested by birds or used for rations formulation are expensive and competed for between poultry and humans and are not always available for small private sector. The challenges that face poultry production necessitate search for alternative feed ingredients to the feed sources that are characterized by high nutritional value, low cost and not competed for between humans and poultry in order to minimize the production cost and maximize profitability. Sclerocarya birrea is a tree species that is adapted to the environment of South Kordofan and produces large amounts of fruits which contain oil and can also give fodder for browsing livestock.

Sclerocarya birrea meal is a widely used feed supplement with high energy content and an amino acid profile close to ideal. The protein quality of SBM is high for poultry, and *Sclerocarya birrea* meal is a particularly good source of lysine, arginine and tryptophan, but it is deficient in methionine plus cysteine, threonine and valine [4].

Marula (*Sclerocarya birrea* Caffra), an indigenous fruit bearing tree, whose seed has a high content of ascorbic acid (2960 mg/100 g), calcium (51mg/100g) and phosphorus (19 mg/100 g), While the fruit pulp of *Sclerocarya birrea* Caffra contains 84% carbohydrate the kernels *S. birrea* Caffra contains 36.7% crude protein. These favorable nutritional attributes make S. birrea Caffra kernel meal a potential protein and energy source in poultry feed [5]. The main objective of this study is to assist in development of low cost sustainable, poultry production systems based on locally available feed resources to maximizing profit of the poultry industry and to study the effect of *Sclerocarya birre*a meal as substitute for super concentrate in growth performance and meat quality of broiler.

Materials and Methods

The Study Area

Dilling is located in the northern part of South Kordofan State (latitudes 9o-12o' N and longitudes 29o -31o' E) within the savannah low rainfall with annual precipitation ranging between 300-500 mm per year. Maximum temperature values are recorded in summer (450C) and minimum values are in the winter which decline to 200 C. Rainfall usually starts in July and ends in October. The northern part of the locality is covered with sandy plains that extend into the Nuba Mountain ranges and valleys interspersed within those plains in the east and some of the cracking clay in the western part of the locality. The main activities practiced by local people are agriculture and animal husbandry, where they raise cattle, sheep, goats and equines. Poultry is of paramount importance since pig is not reared for religious reasons. Also the area is considered as a traditional grazing arena for animals coming from North Kordofan during the dry season. Vegetation is rich in species of trees, shrubs, herbs and grasses. Most of these herbs and shrubs are palatable browse [6]. There are some trees forming the type of vegetation in this region, such as *Sclerocarya birrea* and many others [7].

Oil Extraction and Preparation of the Meal

Fruits were collected from the natural forests around villages in Dilling locality, south to Elobeid city. The clusters were collected, washed and crushed to obtain the internal oil rich kernel. Oil was extracted mechanically in Dallanj oil mill. The kernel cake was subjected to chemical analysis that was conducted to estimate the approximate nutrients ingredients at the Nutrition Laboratory of the Faculty of Forestry and Range, Sudan University of Science and Technology according to the procedures described by AOAC [8].

Amino Acids Determination

Amino acids content of the Sclerocarya birrea kernel meal was determined, by a HPLC at Soba Biochemistry

laboratory of the Ministry of Science and Technology in Khartoum according to the methods described by AOAC [8].

Formulation of Experiment Rations

Five rations A, B, C D and E were formulated for each group as starter and finisher rations taking into account that they should be iso-nitrogenous iso-calorific in composition. Ration A was considered control and contained 5% super-concentrate and free of Sclerocarya birrea kernel meal while the other four rations contained 2.5%, 5%,7.5 and 10% of the kernel cake as a substitute for the super-concentrate and convention protein source (Table 1).

Parameters	I		II		III		IV	
	Starter	Finisher	Starter	Finisher	Starter	Finisher	Starter	Finisher
Energy(Kcl/kg)	3132.5	3149.2	3158. 3	3191.3	3177.4	3189.3	3149.3	3254.4
Protein %	21.9	20	21.9	20.8	21.8	21.7	21.2	21.1
Ca %	1.2	1.1	0.8	0.8	0.7	0.8	0.7	0.8
P %	0.7	0.6	0.5	0.4	0.5	0.5	0.5	0.5
Energy: protein	0.13958333	1.155	0.13680556	1.163	0.14305556	1.165	0.14444444	1.165

Table 1: Nutritive Value of the rations used in the Study Rations.

Experimental Birds Housing and their Rations

The experiment used 200 one day old chicks of Ross strain that were secured from parental stock farm. Upon arrival, the chicks were vaccinated, weighed and assigned to the respective barns (five barns) for 8 weeks. The starter rations were offered in the first four weeks and finisher rations for the remainder of the period for all five treatments. Each barn was divided into four separate units with an area of 1 square meter accommodating 20 birds/unit as four replicates. The floor was deep litter housing system and chicks were transferred periodically to ensure random housing. Drinking water was provided adequately on a permanent basis with the addition of a mixture of vitamins and the barn was provided with lighting continuously for 12 hours at night where each part was provided with a lamp of 50 W at an altitude of 2meters from the ground. The feed was first offered starting from 500g/ unit and then increased gradually depending on chick feed intake and growth (Table 2).

Chemical Composition	Treatments					SE
	A	B	C	D	E	
Moisture	77.7	68	77.7	68	68	2.6
Ash	o.76	0.8	0.88	0.8	0.8	0
Crude Protein	18.4	19	19.3	19	19	0.2
Ether Extract	0.92	0.8	0.89	0.8	1	0.1
*p*H	5.21	5.2	5.34	5.2	5.2	0

Table 2: Chemical Composition of the Experimental Diets.

Data Collection

The initial weight of birds was taken on the first day, when they reached the site, and then on weekly basis to calculate the growth rate. The data obtained also included feed intake and carcass characteristics.

At the end of the 8thweek feeding troughs were lifted and chickens were slaughtered in the early morning and three samples from each group were weighed after slaughter to calculate dressing percentage, abdominal fat, and breast muscle and neck weight. Meat samples were analyzed at the laboratory of the Faculty of Animal Production (Shambat), University of Khartoum to estimate meat pH and chemical composition of the parts.

Statistical Analysis

The experiment was considered as complete randomized design (CRD) and its data were analyzed via the analysis of variance to compare between treatments and detect differences among treatments on feed intake, growth rates, carcass characteristics and feed conversion ratio. The data was first transformed to convert percentages using the

conversion transformation method before conducting statistical analysis. Duncan multiple range test (DMRT) was used to detect differences among treatment means [9]. SAS V9.0 was used as a statistical analysis tool of the data.

Results and Discussion

The chemical composition of *Sclerocarya birrea* kernel meal collected from four sites is illustrated in table 1 The results showed that *Sclerocarya birrea* kernel meal has remarkably high content of CP (12.1 % DM) and NFE (54.5% DM), with moderate content of Ash (4.5 % DM) and low content of EE (1.5 %DM) and CF (21.1%). Mdziniso PM, et al. [10] reported same results for ash (5.43 %DM) and different results for CP (47 % DM) and EE (34.35 % DM), and CF (5.8% g/kg DM). Moreover, Mthiyane MN, et al. [11], reported contradicting results for 47 % CP, 28.8% EE, % Ash and similar CP (470.0–470.21 g/kg DM) and EE (289.6–394 g/kg. Mthiyane MN, et al. [11], reported that The CP content of MSC was found to be 47.21% DM. Mthiyane MN, et al. [11], reported lower values of CP for *Sclerocarya birrea*, they stated that the protein content of Marula seed obtained was 6.17%. This huge difference may be due to the use of the whole nut without removing the oil and kernel thus the protein concentration may have become diluted by the oil and the hard shell of the kernel.

Site	Dry Matter	Moisture	Organic Matter	Crude Protein	Crude Fiber	Nitrogen Free Extract	Ether Extract	Ash
1	93.3	6.7	88.9	12.1	21.1	54.5	1.2	4.4
2	95.6	4.4	90.8	11.9	20.2	57.2	1.5	4.8
3	93.7	6.3	88.6	11.8	21.3	54.4	1.3	5.3
4	94.9	5.1	90	11.4	22.1	55.4	1.1	4.9

Table 3: Chemical Composition of the *Sclerocarya birrea* Kernel Meal Collected from Four Sites (%).

Amino Acids	ug /8g	Mg / 100g	g /100g	g / kg	%
Aspartic acid	194.48	239.76	2.3976	0.23976	23.976
threonine	61.061	763.26	0.76326	0.076326	7.6326
serine	59.687	675.08	0.67508	0.067508	6.7508
Glutamic acid	312.92	3984.53	3.98653	0.398453	39.8453
glycine	124.63	1457.85	1.45785	0.145785	14.5785
Alanine	9.873	1237.43	1.23743	0.123743	12.3743
cysteine	21.615	275.82	0.27582	0.027582	2.7582
Valine	91.432	1225.531	1.22553	0.122553	11.2253
methionine	21.117	274.84	0.27483	0.027483	2.7483
isoleucine	81.845	933.45	0.93345	0.093345	9.33345
leucine	150.34	1706.56	1.70656	0.170656	17.0656
tyrosine	5.088	73.13	0.07313	0.007313	0.7313
phenylalanine	119.48	1579.05	1.57905	0.157905	15.7905
Histidine	25.454	325.17	0.32517	0.032517	3.2517
Lysine	67.79	851.37	0.85137	0.085137	8.5137
Ammonia	143.11	1679.87	1.67987	0.167987	16.7987
Arginine	301.12	3848.6	3.8486	0.38486	38.486

Table 4: Amino Acid Contents of *Sclerocarya birrea* Kernel Meal.

The effects of inclusion of Sclerocarya birrea kernel meal as substitute for super-concentrate as protein source in broiler rations on feed intake is presented in Table 3. It was observed that feed intake increased upon addition of Sclerocarya birrea kernel meal in rations than the conventionally used protein source and super-concentrate

though feed intake increased gradually over a period of time for all groups, with the advanced age, but this intake was the highest (9.76 g) in group C and lowest (7.11g) in Group E. The increased feed intake could be attributed to the fact that the meal contained a significant proportion of essential amino acids and fatty acids that enhanced intake and digestibility. The intake was decreased when the marula seed meal inclusion was greater than 5%. The meal contained higher levels of fat and this is consistent with results found by Habani, et al. [12] who reported that broiler feed intake when an ingredient high in lipids replaced another that had low lipid content. In this regard, Mthiyane MN, et al. [13] reported that the adverse effect of high level of *Sclerocarya birrea* may be due to high level lipid peroxides and mycotoxins, in addition to the suspicious of the presence of high levels of hydrocyanic acid and phytates, which would be countered by dietary supplementation with DL-methionine and phytase.

The impact of inclusion of the kernel cake as substitute for concentrate in broiler rations on the broiler live weight and average weekly increase is presented in (Table 4). There have been significant differences among bird groups in feed intake and live body weight. The heaviest live weight (1632.2 g) was recorded in group C and lighter live weight (511.9 g) was in group E and that may be due to differences in feed intake. These findings are consistent with those reported by Cosby DE, et al. [14], who found that the presence of these substances that act as inhibitory to feed intake impede growth and hinder the utilization of nutrients in birds and must be removed and disposed of for the desired production rates. It was also found that the average weekly gained weight was highest (375.8 g) in group I and lower (104.9 g) in C, and that may be due to the effect of source of protein on the amount of feed intake in chickens. The results of this study are similar with findings reported by Harper AE [15], who reported that change of protein source could result in a change in the content of amino acids of the feed leading to an imbalance in feed intake very quickly in the chicken. That was shown in the decline in growth that was followed by a change of the dietary protein. The decreased weight gain was not the result of direct response to that change of protein source but as much as it was a reflection of the content of amino and essential fatty acids (Table 2).

Similar results were obtained by Mthiyane MN, et al. [13] who stated a significant decrease in the live weight ($P < 0.001$), plucked weight ($P < 0.001$), dressed weight ($P < 0.001$), liver weight ($P < 0.001$) and neck weight ($P < 0.05$) of broilers as the level of MSC increased in the diet also Mlambo V, et al. [16] also observed that dietary MSC supplementation significantly decreased the live weight, dressed weight, dressing percentage, length of feathers, as well as weights of the wing, breast, thigh, drumstick, shank, abdominal fat, liver, gizzard, heart and intestines in broilers.

The Effects of Replacement Super-Concentrate by *Sclerocarya birrea* Kernel Meal on Broiler Carcass and Parts Weight

It was found that the average weight at slaughter was higher (1282.2 g) in group C and the lowest (211.9 g) in group E (Table 4). Dressing percentage was the highest (78.5 %) in group A and lowest (41.4 %) in group C (Table 4). This is due to the amount of feed intake and the amount of the kernel cake that the rations contained. The findings of this study are in line with those of Ahmed Abdo ZM [17], where she pointed out that the presence of saponin lead to a reduction in the rate of growth due to the lack of feed intake.

Parameters	A	B	C	D	E	SD
Live weight (g)	1632	758	772	512	512	278
carcasses weight (g)	1282	428	212	212	212	267
Dressing (%)	78.5	56.4	41.4	41.4	41.4	8. 76
Average breast muscle weight(g)	223.4	195	177	177	177	10.6
average leg weight(g)	145.7	126	105	105	105	9.64
Average abdominal fat weight (g)	30	30	20	20	20	2.72
Average neck weight (g)	100	80	70	70	70	7.2

Table 5: Live Weight, Carcass and Cuts Weight as Affected by the Level *Sclerocarya birrea* Kernel Meal Treatments.

The study found that the weight of muscles of the legs, chest and neck was higher in group C (145.7, 223.3, 100 g, respectively), and lower in Group E (104.80, 177.27 0.70 g (41.4 %), respectively) (Table 5). That could be attributed to the amount of feed intake by birds as group E ratio contained high kernel cake instead of the concentrate and groundnut seed cake, which had a negative impact on the average rates of carcass cuts as a result of the presence of inhibiting factors for growth. Those result are consistent with those reported by Ahmed Abdo ZM [17] where she indicated that there are

benefits to use protein sources of plant origin except that they contain constituents that are characterized having growth retardant properties which limit or impede the use of these sources in nutrition in its raw material form and they must be removed and disposed of to get the desired production traits.

The percentage of abdominal fat was higher (30g) in group E followed by A, B and lowest in group C (Table 4). That may be due to the lipid content and difference in the rate of growth and this is consistent with results reported by Mac N [18], Abou El wafa [19], Magagula BS [20] Zhang YN, et al. [21], who attributed most of the difference in the amount of abdominal fat to differences in the rate of growth and found that the decline in the proportion of energy in the feed or the high proportion of protein leads to increase in their growth rates, thus increase the amount of abdominal fat and the size of the back of the abdominal fat. Moisture content of meat was higher (77.74 %) in group C and lower (68.20 %) in group E. The ash was close in group C and B and A (0.76 and 0.77%, respectively) and higher (0.88 %) in D and E, while the protein was found to be similar in ratio in all groups and also the pH (Table 6). This is consistent with the findings reported by Abou El wafa [19], Magagula BS [20], who showed that the carcass and blood components were not affected by sources of protein either of plant or animal origin in protein and total amino acids content [18-21].

The juiciness was higher (1 %) in group E and lower (0.77%) in A B, D and C Table 6 and this could be due to increase in the percentage of body fat due to the high fat diet in group III, and this is consistent with Mac N [18], who reported that the body weight and percentage of fat in the abdomen increases when the level of fat in the meat chicken feed is increased leading higher Juiciness.

Parameters measured	A	B	C	D	E	SE
No of chicks	40	40	40	40	40	0
Weeks on trial	8	8	8	8	8	0
Average initial weight (g)	35	35	35	35	35	0
Average final weight (g)	857.6	797.6	1632	611.9	757.6	217.5
Average total weight gain (g)	597.2	722.6	776.9	676.9	722.6	237.5
Average daily gain (g)	53.68	44.03	64.98	44.98	47.03	9.54
Average total feed intake (g)	39375	28348	39017	37017	37348	435.6
Average daily feed intake (g)	7.36	8.98	9.76	9.16	7.11	0.85
Feed conversion ratio	0.703	0.506	0.38	0.38	0.506	0.08
Feed cost SDG	255.8	243.6	232.3	228.3	212.6	8.93

SDG= Sudanese Pound; SE Standard Error

Table 6: Performance of Broiler Chick Fed Rations Containing Different levels of *Sclerocarya birrea* Kernel Cake.

Conclusion

The study showed that *Sclerocarya birrea* kernel cake contained a high proportion of amino acids, crude protein and ether extract. Hence it was concluded that kernel meal might be used as substitute for super-concentrate in broiler rations to reduce feeding cost taking in consideration that it contained some anti-nutritional factors such as phytates, tannins and saponins.

Recommendations

The study recommends more research to be conducted to elucidate effects of use of *Sclerocarya birrea* kernel meal as substitute for the expensive super concentrate and groundnut meat as source of protein and the role of the growth inhibitory substances found in the meat such as saponin to take advantage of these fruits that are found in great abundance and collected at very low cost.

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