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# Effect of Processing Methods on the Utilization of Sorrel Seed Meal by Broilers

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**Abstract:** An experiment was conducted to determine the productive parameters and carcass characteristics of broilers fed sorrel seed meal. A total of 160 Anak broiler chickens were used for the experiment. The birds were randomly allocated to four dietary treatments containing sorrel seed meal with different processing methods; Raw sorrel seed, roasted sorrel seed, boiled and dried sorrel seed and soaked and dried sorrel seed. The criteria for the assessment were growth performance, digestibility and carcass characteristics. Mean daily weight gain and daily feed intake of the birds at starter phase varied from 22.36-30.69 g/bird and 65.62-68.83 g/bird. The daily weight gain for the finisher phase range 47.66-53.57g/bird and 120.72-145.14 g/bird for daily feed intake at finisher phase. The result of daily weight gain and feed intake of combined phase show significant difference ($p>0.05$). Birds on boiled and dried sorrel seed meal had the highest daily weight gain (42.13 g/day) and daily feed intake (105.26 g/day). The nutrient digestibility were generally high for all nutrients (above 60%) except crude fibre which range between 47.89-51.95%. The results of the carcass show significant far all the body part except for some organs spleen, liver and intestine which showed no significant difference ($p<0.05$).

**Key words:** Sorrel seed, broilers, chicken, birds

## INTRODUCTION

The increase in human population after the Second World War warranted an increase in the production of some highly prolific fast growing proteinous animals to limit malnutrition. Ademosun and Korango (1985) stated that the problem of protein malnutrition is real in most developing countries especially those located in warm humid tropics where the level of animal protein intake represents about one tenth of the level of intake in some advanced countries. Ahamefule *et al*. (2000) estimated the average protein intake of Nigerians to be about 8.27 g per caput per day. According to Marquisit (1985), the protein intake in Nigeria is 5.5 g while 28 g per person per day was recommended by the British Medical Association (1993). The poor nutritional situation in Nigeria is very glaring owing to the wide gap between the estimated protein requirement and the actual protein consumed. In order to bridge the gap, there is need to intensify effort towards increasing livestock production. However, increasing the production of ruminant animals (cattle, sheep and goat) is becoming difficult as a result of human activities on the available land for grazing. Hence, the production of poultry increased. But the development of the poultry industry in Nigeria is still suffering from the escalated cost of feed. Feed cost accounts for about 60-70% of the total cost of poultry production in Nigeria (Nworgu *et al*., 1999). The high cost of feed is largely due to the exorbitant price and scarcity of conventional feed ingredients (Apata and Ojo, 2000).

The price of Groundnut Cake (GNC) and soybean meal has more than doubled over the past few years as a result of the low groundnut and soybeans production coupled with the high demand for the cake and soybean meal for human and animal consumption.

Thus, depending on groundnut cake and soybean meal as the sole source of protein in poultry diet is gradually becoming economically impracticable in Nigeria. Research into new sources of plant protein for poultry should therefore be intensified.

*Hibiscus sabdariffa* is a popular plant (belonging to the family *Malvceae*) and is presently cultivated widely in the old and new world tropics and subtropics. The presumed origin is South East Asia in the region of India to Malaysia. It has long been cultivated in Africa. Probably, it was carried by slaves to the new world (Duke, 1999). *Hibiscus sabdariffa* is suitable for tropical climate with well distributed rainfall of 1500-2000 mm yearly, from sea-level to about 600m altitude. The soil preparation should be deep, about 20 cm and seed rate (11-22 kg/ha) depending on the soil. Soil is drilled about 15 cm by 15 cm at beginning of rainy season and seeds planted at depth of about 0.5 cm. Broadcasting is not recommended (Duke, 2000).

*Hibiscus sabdariffa* locally known as "Yakuwa" is a well-adapted crop in the semi-arid zone of West Africa including Nigeria and it is generally planted as a border crop. The leaves are used as vegetable and the floral parts in the preparation of "Sobo", a local drink. The stem provides fibre and the seeds are eaten by

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scavenging poultry (Philips, 1977). The seed of *Hibiscuss sabdariffa* is said to have high protein value and it is on account of its protein content that it is well priced for human consumption in French West Africa (Mali, Guinea, Burkina Faso, Cote D' Voire). However, in Nigeria larger quantities of the seeds of this crop are wasted on the farm annually and just enough being collected and stored for planting.

Inspite of the numerous advantages of sorrel, the seeds in their raw state are known to have bitter taste, which is attributed to anti-nutritional factors, most probably tannins. Tannins are known to have detrimental effect on the health and growth of animals (Jansman, 1993). These anti-nutritional factors could be inactivated by heat treatment (Price *et al*., 1980; Bressani *et al*., 1982). Humid or moist heat treatment and dry heat treatment and soaking in water are some of the recommended ways of eliminating anti-nutritional factors in feedstuff (Price *et al*., 1979). The objective of the study were to evaluate the effect of different processing methods of sorrel seeds, such as: roasting, boiling and soaking on productive performance of broilers.

## MATERIALS AND METHODS

**Experimental site:** The study was conducted at the Poultry Production Unit (PPU) of Borno State Ministry of Agriculture and Natural Resources Maiduguri. The farm had standard deep litter houses. The study area lies between Latitude 11°-15 inch North and longitude 30°-05 inch East and had an altitude of 354 m above sea level (Alaku, 1983). It is characterized by hot and dry climate and short duration of erratic rainfall (3-4) months per annum and a long period of dry season. Ambient temperatures are low in December to January ranging from 15-19°C and high in March to June, ranging from 33-44°C and low relative humidity ranging from 5-43.5% (Alaku, 1983).

### Experimental stock/plant

**Source and processing of sorrel seeds:** The sorrel seeds used in this study were procured locally around Maiduguri and processed as follows:

- 25 kg of raw sorrel seeds were cleaned and milled and incorporated into the diets of broilers.
- 25 kg of sorrel seeds were cleaned and roasted for 40 min in frying pan at 100°C and cool under shed for a day, then milled and incorporated into the diets of broilers.
- 25 kg of sorrel seeds were cleaned and boiled in water for 30 min at 100°C in an aluminum pot, sun-dried for three days, then milled and incorporated into the diets of cockerels.
- 25 kg of sorrel seeds were cleaned and soaked in water for 12 h in a plastic basin, sun dried for three days then milled and incorporated into the diets of cockerels.

**Experimental birds and management:** One hundred and sixty (160) 7 days-old Anak 2000 broiler chicks were used for the study in a completely randomized design. The chicks were individually weighed and randomly selected and allocated to each of the four different types of processing methods. Each type of processing method consists of forty birds with 10 birds per replicate. Chicks were brooded under 100 watts electric bulbs. The experiment lasted for seven weeks. All management were adhered to.

The birds were vaccinated against Gumboro, at two and five weeks of age while New castle disease vaccine (Lasota) was administered at three weeks of age. Antistress was given each time after administration of drugs. Feed and water was given *ad libitum*. Data on feed intake and liveweight gain were collected on daily and weekly basis respectively. Feed conversion ratio was calculate from data on feed intake and weight gain. The processing methods comprised of four diets which contain Raw Sorrel Seed (RSS), Roasted Sorrel Seed (ROSS), Boiled and Dried Sorrel Seed (BDSS) and Soaked and Dried Sorrel Seed (SDSS) in diets as shown in Table 3 and 4.

**Carcass analysis:** At the end of the experiment (7 weeks) 64 chickens, three from each replicate was slaughtered to determine the carcass characteristics such as cut-up parts and organ weights.

**Chemical analysis:** The experimental diets were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), ash according to AOAC (2002) while tannin was determined using the method of Polshettiwar *et al*. (2007).

**Statistical analysis:** Data obtained was subjected to analysis of variance. Where significant differences occurred, the means will be separated using Duncan multiple range F-test of the SAS (1988) options.

## RESULTS

**Proximate composition of raw and differently processed sorrel seed:** The proximate composition of differently processed sorrel seed are presented in Table 1. The crude protein content of the raw, roasted, boiled and soaked were 26.00, 25.40, 27.10 and 25.85% respectively. The crude protein of the boiled sorrel seeds was slightly higher than the rest. The crude fibre levels were between 13.10% and 15.50% and the ether extract levels were 16.00, 19.00, 23.00 and 16.00% for raw, roasted, boiled and soaked respectively. The ash in raw and boiled sorrel seed meal was relatively lower than the values in the roasted and soaked sorrel seed meal. The Nitrogen Free Extract (NFE) which represent the readily available carbohydrates in the sorrel seed were 36.00, 33.60, 29.80 and 33.65 in the raw, roasted, boiled

Table 1: Proximate composition, Tannin proportion and reduction level of differently processed sorrel seed meal

| Parameter (%) | RSSM | ROSSM | BDSSM | SDSSM |
|---|---|---|---|---|
| Dry matter | 94.30 | 94.20 | 90.40 | 91.55 |
| Moisture content | 5.70 | 5.80 | 9.60 | 8.45 |
| Crude protein | 26.00 | 25.40 | 27.10 | 25.85 |
| Crude fibre | 15.00 | 14.00 | 13.10 | 15.50 |
| Ether extract | 16.00 | 19.00 | 23.00 | 16.00 |
| Ash | 7.00 | 8.00 | 7.00 | 9.00 |
| Nitrogen Free Extract (NFE) | 36.00 | 33.60 | 29.80 | 33.65 |
| Tannins level (%) | 2.50 | 2.00 | 0.80 | 1.60 |
| % Reduction of tannins | - | 20.00 | 68.00 | 36.00 |

RSS = Raw Sorrel Seed; ROSS = Roasted Sorrel Seed; BDSS = Boiled and Dried Sorrel Seed; SDSS = Soaked and Dried Sorrel Seed

Table 2: Proximate composition of treatment diets containing differently processed sorrel seed meal at the starter phase

| Parametert (%) | RSSM | ROSSM | BDSSM | SDSSM |
|---|---|---|---|---|
| Dry matter | 93.70 | 93.90 | 93.10 | 93.80 |
| Moisture content | 6.30 | 6.10 | 6.90 | 6.20 |
| Crude protein | 22.31 | 22.40 | 22.80 | 22.20 |
| Crude fibre | 7.71 | 8.57 | 7.75 | 8.85 |
| Ether extract | 5.50 | 7.50 | 8.50 | 7.50 |
| Ash | 2.00 | 2.50 | 2.50 | 3.00 |
| Nitrogen free extract (NFE) | 62.48 | 59.03 | 58.45 | 58.45 |

RSS = Raw Sorrel Seed; ROSS = Roasted Sorrel Seed; BDSS = Boiled and Dried Sorrel Seed; SDSS = Soaked and Dried Sorrel Seed

Table 3: Proximate composition of treatment diets containing differently processed sorrel seed meal at the finisher phase

| Parameter (%) | RSSM | ROSSM | BDSSM | SDSSM |
|---|---|---|---|---|
| Dry matter | 92.80 | 93.40 | 92.60 | 93.40 |
| Moisture content | 7.20 | 6.60 | 7.40 | 6.60 |
| Crude protein | 19.40 | 19.50 | 19.60 | 19.00 |
| Crude fibre | 7.00 | 8.50 | 6.00 | 7.10 |
| Ether extract | 5.00 | 5.50 | 7.00 | 6.50 |
| Ash | 3.50 | 2.00 | 2.00 | 2.50 |
| Nitrogen Free Extract (NFE) | 65.10 | 64.40 | 65.40 | 64.90 |

RSS = Raw Sorrel Seed; ROSS = Roasted Sorrel Seed; BDSS = Boiled and Dried Sorrel Seed; SDSS = Soaked and Dried Sorrel Seed

and soaked sorrel seed meal respectively. The higher level of ash in roasted and soaked sorrel seed meal may indicate higher calcium and phosphorus level. Processing resulted in a decrease in the levels of tannin, with roasted, boiled and soaked accounting for 20, 68 and 36% reduction respectively. Boiling proved to be better than roasting and soaking in reducing the levels of tannin in the sorrel seed.

**Tannin content:** Tannin values of raw, roasted, boiled and soaked seed were 2.50%, 2.00%, 0.80% and 1.60% respectively as shown in Table 1. The reduction in the levels of tannins in the processed sorrel seeds was due to the processing method adopted. Processing therefore resulted in the decrease in the levels of tannin with roasting, boiling and soaking which accounted for 20, 68 and 36% reduction in the tannin levels respectively. Boiling which led to 68% decrease in tannin content was better than roasting and soaking in reducing the levels of tannins in sorrel seeds.

**Proximate compositions of the experimental diets:** The proximate composition of the experimental diets for broiler starter and finisher is presented in Table 2 and 3 respectively. The starter diet contained 22.31, 22.40, 22.80 and 22.20% crude protein, while the finisher diets had 19.40, 19.50, 19.60 and 19.00% for the raw, roasted, boiled and soaked sorrel seed meal respectively.

The Ether Extract (EE) ranged from 5.50-8.50% and 5.00-7.00% for broiler starter and finisher diets respectively. The crude fibre levels obtained for broiler starter and finisher diet ranged from 7.71-8.85 and 6.00-8.50 for the raw, roasted, boiled and soaked sorrel seed meal respectively.

The ash content of starter and finisher diets ranged from 2.00-3.00 and 2.00-3.50% and Nitrogen-free extract 58.54-62.48% and 64.40-65.40% for starter and finisher diets respectively.

**Productive performance:** The productive performance of broiler chickens fed on raw and differently processed sorrel seed meals are presented in Table 4.

The initial weight (g/bird) showed no significant ($p>0.05$) difference among the types of different processing methods with means of 127.25, 126.25, 128.50 and 124.00 g/birds for the raw, roasted, boiled and soaked sorrel seed meal respectively.

The starter weight at week 5 revealed significant ($p<0.05$) difference and values were 804.50, 680.30, 1161.30 and 867.50 g/bird for diets formulated with raw, roasted, boiled and soaked sorrel seed meal. The birds which consumed boiled sorrel seed meal performed better than birds fed on the raw, roasted and soaked sorrel seed meal respectively.

The final live weights are presented in Table 4. The overall means were 1970.00, 2025.00, 2357.50 and 1975.00 g/birds for the birds fed on the raw, roasted, boiled and soaked sorrel seed meal respectively. There were significant ($p<0.05$) differences among the type of different processing methods of sorrel seed meal with birds fed on boiled sorrel seed meal having significantly ($p<0.05$) heavier body weight than those fed on the raw, soaked and roasted sorrel seed meal respectively. The effectiveness of boiling of the sorrel seed was clearly shown in the heavier final weight of the birds.

With respect to daily weight gain, there were significant ($p<0.05$) differences among the types of different processing methods of sorrel seed meal. Birds fed on boiled sorrel seed meal showed positive body weight gains with 30.69 g/bird in starter phase, 53.57 g/bird in

Table 4: Productive performance of broiler chickens fed raw and differently processed Sorrel Seed Meal (SSM)

| Parameters | RSSM | ROSSM | BDSSM | SDSSM | SEM |
|---|---|---|---|---|---|
| Initial weight g/bird | 127.25 | 126.25 | 128.50 | 124.00 | 1.95 |
| Weight at 5 weeks g/bird | 804.50$^{d}$ | 880.30$^{b}$ | 1161.30$^{a}$ | 867.50$^{c}$ | 1.38* |
| Final weight g/bird | 1970.00$^{c}$ | 2025.00$^{b}$ | 2357.50$^{a}$ | 1975.00$^{c}$ | 2.05* |
| Feed cost N/kg | 29.72 | 29.72 | 29.72 | 29.72 | 0.28* |
| Mortality | 3 | 1 | 2 | 2 | - |
| Mortality percentage | 7.50 | 2.50 | 5.00 | 5.00 | - |
| **Starter phase** | | | | | |
| Daily weight gain g/bird | 22.36$^{b}$ | 23.42$^{b}$ | 30.69$^{a}$ | 23.10$^{b}$ | 0.39* |
| Daily feed intake g/bird | 69.45$^{a}$ | 68.83$^{a}$ | 65.62$^{b}$ | 68.70$^{a}$ | 0.51* |
| Feed conversion ratio | 3.11$^{a}$ | 2.93$^{b}$ | 2.13$^{b}$ | 2.77$^{b}$ | 0.23* |
| Feed cost/kg gain | 96.74$^{a}$ | 92.26$^{b}$ | 66.30$^{b}$ | 93.32$^{a}$ | 0.98* |
| **Finisher phase** | | | | | |
| Daily weight gain g/bird | 47.66$^{b}$ | 48.86$^{b}$ | 53.57$^{a}$ | 47.00$^{b}$ | 0.68* |
| Daily feed intake g/bird | 130.69$^{b}$ | 120.72$^{c}$ | 145.14$^{a}$ | 134.32$^{b}$ | 3.05* |
| Feed conversion ratio | 2.72 | 2.61 | 2.70 | 2.85 | 0.86 |
| Feed cost/kg gain | 77.19$^{b}$ | 69.89$^{c}$ | 66.60$^{b}$ | 80.82$^{a}$ | 0.59* |
| **Combined phase** | | | | | |
| Daily weight gain g/bird | 35.13$^{c}$ | 36.14$^{c}$ | 42.13$^{a}$ | 35.05$^{c}$ | 0.31* |
| Daily feed intake g/bird | 100.07$^{c}$ | 94.78$^{d}$ | 105.26$^{a}$ | 101.76$^{b}$ | 0.29* |
| Feed conversion ratio | 2.91 | 2.77 | 2.42 | 2.92 | 0.21 |
| Feed cost/kg gain | 84.66$^{a}$ | 77.95$^{b}$ | 74.25$^{c}$ | 86.28$^{a}$ | 0.29* |

$^{a,b,c}$Means within the same row bearing different superscripts differ significantly ($p<0.05$). SEM = Standard Error of Means; NS = Not significant ($p>0.05$); * Significant difference ($p<0.05$)

Table 5: Nutrient digestibility

| Nutrient digestibility | RSS | ROSS | BDSS | SDSS | SEM |
|---|---|---|---|---|---|
| Dry Matter (DM) | 78.18$^{a}$ | 76.59$^{a}$ | 70.91$^{b}$ | 79.41$^{a}$ | 4.52* |
| Crude Protein (CP) | 71.83$^{a}$ | 70.72$^{a}$ | 68.25$^{b}$ | 72.73$^{a}$ | 2.80* |
| Crude Fibre (CF) | 50.52$^{a}$ | 51.95$^{a}$ | 47.89$^{b}$ | 51.13$^{a}$ | 2.57* |
| Ether Extract (EE) | 79.82$^{a}$ | 65.11$^{c}$ | 63.04$^{c}$ | 70.06$^{b}$ | 5.25* |
| Ash | 65.54$^{b}$ | 60.59$^{bc}$ | 61.35$^{bc}$ | 71.93$^{a}$ | 2.98* |
| Nitrogen Free Extract (NFE) | 66.12$^{c}$ | 73.78$^{b}$ | 78.86$^{a}$ | 68.16$^{c}$ | 3.48* |

$^{a,b,c}$Means within the same row bearing different superscripts differ significantly ($p<0.05$). SEM = Standard Error of Means; NS = Not Significant ($p>0.05$);* = Significant difference ($p<0.05$)

finisher phase and 42.13 g/bird in the combined phase while those on raw sorrel seed meal recorded the least weight gain in the starter phase and soaked sorrel seed meal in finisher and combined phase. The effectiveness of boiling of sorrel seed in enhancing nutritive value of the meal was clearly indicated.

The highest daily feed intake (69.45 g/bird) was observed in birds fed on raw sorrel seed meal in the starter phase, (145.14 g/bird) in the birds fed on boiled sorrel seed meal in the finisher and combined phase, while the least (68.70 g/bird) was recorded in birds fed on soaked and roasted sorrel seed meal in starter phase, finisher and combined phase 120.72 and 94.78 g/bird. Daily feed intake of chicken on diets containing raw and boiled sorrel seed meal was superior ($p<0.05$) to those birds fed on roasted and soaked sorrel seed meal respectively. Birds fed on roasted and soaked sorrel seed meals in starter phase, raw and soaked sorrel seed meal in finisher phase, raw and soaked sorrel seed meal in combined phase recorded similar daily feed intakes.

The feed conversion ratio did not differ ($p>0.05$) significantly in the finisher phase and combined phase but there was a significant ($p<0.05$) difference in the starter phase. The birds fed on boiled sorrel seed meal exhibited significant ($p<0.05$) difference in feed conversion ratio in the starter phase. The values obtained indicate that all the types of different processing methods in the three phases of the study exhibited better feed conversion ratio except in the bird fed on raw sorrel seed meal starter phase that indicated significantly ($p<0.05$) low value.

The economic analysis data for broilers fed on raw and differently processed sorrel seed meal are presented in Table 4. The feed cost (Naira/kg) were similar for all the types of different processing methods and the cost per kg gain varied from Naira 66.30-Naira 96.74 starter phase, Naira 66.60-Naira 80.82 finisher phase and Naira 74.25-Naira 86.28 for the combined respectively.

Similarly, the total feed cost for all the birds fed on the boiled sorrel seed meal diet were lower than that of the raw, roasted and soaked sorrel seed meals in the starter and combined phase, but in the finisher bird fed on roasted sorrel seed meal had the lowest feed cost per kg gain. Generally, the inclusion of sorrel seed meal in the diets resulted in the reduction of the feed cost in all the types of different processing methods. The feed costs per kg gain were better in the diets containing boiled sorrel seed meal in the three phases of the study.

Table 6: Carcass characteristics of broiler chickens fed raw and differently Processed Sorrel Seed Meal (SSM)

| | Types of processing methods | | | | |
|---|---|---|---|---|---|
| Parameters (g) | RSSM | RDSSM | BDSSM | SDSSM | SEM |
| Carcass weight | 1160.00$^{c}$ | 1465.00$^{b}$ | 1660.00$^{a}$ | 1395.00$^{b}$ | 53.865* |
| Drumstick | 167.39$^{c}$ | 221.26$^{b}$ | 249.75$^{a}$ | 212.50$^{b}$ | 3.43* |
| Thighs | 124.43$^{c}$ | 125.18$^{bc}$ | 147.94$^{a}$ | 130.65$^{b}$ | 1.43* |
| Wings | 85.24$^{b}$ | 76.70$^{c}$ | 93.80$^{a}$ | 95.56$^{a}$ | 2.28* |
| Breast muscle | 175.09$^{b}$ | 114.10$^{c}$ | 191.92$^{a}$ | 191.93$^{a}$ | 4.75* |
| Feather weight (g) | 72.00$^{b}$ | 90.00$^{a}$ | 65.00$^{c}$ | 88.00$^{a}$ | 0.11* |
| Head (g) | 80.61$^{bc}$ | 84.00$^{b}$ | 98.91$^{a}$ | 83.10$^{b}$ | 9.00* |
| Neck (g) | 84.00$^{b}$ | 85.97$^{b}$ | 100.27$^{a}$ | 87.24$^{b}$ | 9.70* |
| Gizzard (g) | 70.65$^{b}$ | 71.40$^{b}$ | 79.62$^{a}$ | 73.42$^{ab}$ | 8.31* |
| Spleen (g) | 1.30 | 1.40 | 1.82 | 1.60 | 0.78$^{NS}$ |
| Liver (g) | 30.21 | 32.47 | 35.01 | 33.50 | 3.50$^{NS}$ |
| Intestine (g) | 56.38 | 57.09 | 60.24 | 58.29 | 5.10$^{NS}$ |
| Chest (g) | 164.18$^{c}$ | 167.71$^{c}$ | 180.74$^{a}$ | 176.74$^{b}$ | 18.21* |
| Legs (g) | 55.29$^{b}$ | 76.61$^{ab}$ | 80.32$^{a}$ | 77.85$^{ab}$ | 4.44* |
| Heart (g) | 5.82$^{c}$ | 6.01$^{b}$ | 7.81$^{a}$ | 5.10$^{c}$ | 10.41* |
| Lungs (g) | 9.42$^{b}$ | 9.12$^{b}$ | 12.90$^{a}$ | 11.82$^{a}$ | 12.01* |
| Back (g) | 180.22$^{ab}$ | 74.21$^{b}$ | 191.05$^{a}$ | 179.01$^{ab}$ | 21.10* |
| Abdominal fats (g) | 53.97$^{d}$ | 64.09$^{c}$ | 102.11$^{a}$ | 87.23$^{b}$ | 14.78* |

$^{a,b,c}$Means within the same row bearing different superscript differ significantly ($p<0.05$). SEM = Standard Error of Means; NS = Not Significant ($p>0.05$); * = Significant difference ($p<0.05$); RSS = Raw Sorrel Seed; ROSS = Roasted Sorrel Seed; BDSS = Boiled and Dried Sorrel Seed; SDSS = Soaked and Dried Sorrel Seed

Mortality was recorded in birds fed on raw sorrel seed meal having the highest (7.5%) followed by birds fed on boiled, roasted and soaked sorrel seed meal (5%) and birds fed on roasted and soaked sorrel seed meal recorded (2.50%) respectively. There was no evidence of any disease in all the birds fed on different types of processing methods of sorrel seed meal. The deaths coincided with the time of high environmental temperature and post-mortem results showed that the birds died of heat prostration.

**Nutrient digestibility:** The result of the nutrient digestibility is shown in Table 5. Generally, nutrients digestibility was high for except for crude fibre which less than 52% for all the processing methods with the least (47.89%) for boiled and dried sorrel seed.

**Carcass characteristics:** The carcass data are presented in Table 6. The result showed significant ($p<0.05$) differences in the carcass weight, drumstick, thighs, wings and breast muscle weight among the types of different processing methods.

The higher value of the carcass weight indicated significant ($p<0.05$) difference in birds fed on boiled sorrel seed meal with 68% tannin reduction followed by those on the roasted and soaked sorrel seed meal with 20% and 36% respectively. The least value was in birds fed on raw sorrel seed meal with 0% reduction of tannin.

## DISCUSSION

**Proximate composition of raw and differently processed sorrel seed:** The higher Crude Protein (CP) level of the boiled sorrel seeds may be attributed to processing method. Similar result was observed by Akinmutimi (2001) who subjected legumes seeds to moist-heating and reported a slight increase in the Crude Protein (CP) levels of the feed. The Crude Fibre (CF) levels were similar to 15.32% reported by Samy (1999). The Crude Fibre (CF) for the boiled and roasted was lower than the others which could be due to processing method. The Ether Extract (EE) levels were within the range given by FAO (1968). The higher level of Ether Extract (EE) in the boiled sorrel seeds could be attributed to the decrease in the non-lipid component of the sorrel seeds during cooking. The lower levels of the Nitrogen Free Extract (NFE) in the boiled sorrel seeds may be due to the high loss of NFE in water during boiling as previously reported by Samy (1999). Similarly the higher levels of protein and ash in the processed sorrel seeds may confirm the loss of more soluble components of the seeds in favour of the protein and ash.

**Tannin content:** The reduction in the levels of tannins in the processed sorrel seeds was due to the processing methods adopted. This observation was in agreement with the report of Price *et al.* (1979) and Njidda (2011) who stated that soaking in water tends to eliminate the anti-nutritional factors in feedstuff and makes them (tannins) nutritionally less active. Bressani *et al.* (1982) also stated that humid or moist heating reduces tannins contents of feedstuff. The decrease in the tannin content of legumes during soaking may be due to the leaching out of the tannins into the soaking water.

Processing therefore resulted in decrease in the levels of tannin with roasting, boiling and soaking accounting for 20, 68 and 36% reduction in the tannin levels

respectively. Boiling which led to 68% decrease in tannin was better than roasting and soaking in reducing the levels of tannins in sorrel seed.

**Proximate composition of the experimental diets (broiler starter and finisher mash):** Although the protein values showed some variations, they were close to the recommended range of 21-24% for broiler starter diets and 18-20% for broiler finisher diet (Kekeocha, 1984). Similarly Olomu (1995) recommended a range of 20-22% for broiler starter diets and 18-21% for broiler finisher diets respectively.

The Ether Extract (EE) range of 5.50-8.50% and 5.00-7.00% for broiler starter and finisher diets agreed with the 5-7% recommended by NRC (1996) in a diet. The crude fibre level obtained in this study for broiler starter and finisher diet ranges from 7.71-8.85% and 6.00-8.50% respectively and were higher than the level of 2.10, 2.70 and 4.30 recommended by Olomu (1995). The ash and nitrogen free extract of the starter and finisher diet agree with the range of 3.00-2.70 and 66.20-75.80% recommended by Olomu (1995) but the nitrogen-free extract did not agree with the recommended values by Olomu (1995). These values can provide the necessary minerals such as calcium and phosphorus needed for development of bones.

**Productive performance**

**Starter phase (g/bird):** A comparison of weight at 5 weeks of age (starter phase) revealed significant differences at this period of the study. The birds which consumed 25% boiled sorrel seed meal diet performed much better than their counterparts that were fed on raw, roasted and soaked sorrel seed meal. The body weight in this study did not agree with the mean weight of 1250 g/bird of broiler at 5 weeks reported by NRC (1984), but the performance of the birds fed on boiled sorrel seed meal was higher. The improved performance may be as a result of reduction of tannins contents in the feedstuff as reported by Bressani *et al.* (1982).

**Final weight (g/bird):** These values agreed with the report of Asamoah (1982) who reported that broiler chicken weighs 1-3 kgs live weight at age of 9-10 weeks. The significantly heavier birds among the types of different processing methods was indicated in birds fed on roasted and boiled sorrel seed meal and the significantly lower live weight in birds fed on raw and soaked sorrel seed meal may be related to the slightly poorer Feed Conversion Ratio (FCR) of the birds fed on raw and soaked sorrel seed meal. The live weight of the birds followed the pattern of the feed conversion ratio of the birds.

Although the effect of boiling on the sorrel seed was not clearly indicated in the final weight of the birds, it could be that boiling enhanced the solubilization of some nutrient into the boiling water. The poor performance of birds fed on raw sorrel seed meal could be as a result of anti-nutritional factors (Tannins) which are known to have detrimental effect on the health and growth of animals (Jansman *et al.*, 1989).

The result of this study however, did not agree with the recommendation of Olomu (1995) who recommended that at nine weeks the final live weight of broilers should be about 2495 g.

**Daily weight gain (g/bird):** The results indicate no significant differences among the types of processing methods. The birds fed on boiled sorrel seed meal had significantly higher daily weight gain than birds fed on raw, roasted and soaked sorrel seed meal. Therefore, boiled sorrel seed meal in broiler diet had no adverse effect on the weight gain. This observation agreed with the report of Price *et al.* (1980) which indicated that anti-nutritional factors could be inactivated by heat treatment. Similarly, Price *et al.* (1979) reported that humid or moist heat treatment, dry heat treatment and soaking in water were also effective ways of eliminating anti-nutritional factors in feeds. This could be the reason that birds fed on roasted and boiled sorrel seed meal were slightly better in daily weight gain than birds fed on raw sorrel seed meal. The lower performance of the birds fed on raw sorrel seed meal could be as a result of anti-nutritional factors (Tannins) in raw sorrel seed meal which is known to have effect on the health and growth of the animals (Jansman, 1993).

Similar result were obtained on the daily weight gain of the starter phase, finisher phase and combined phase with birds fed on boiled sorrel seed meal exhibiting significant difference in the three phases of the study, while birds fed on roasted and soaked sorrel seed meal had slightly higher daily weight gain than birds fed on raw sorrel seed meal. The levels were adequate to meet the amino acid needs of the birds. The methionine levels in the processed diets probably improved the biological value of the feeds. Formulation to meet the amino acids needs of the birds rather than the general crude protein level is important because it does not only reduce feed cost but it also results in improved feed conversion ratio (Day, 1983).

**Daily feed intake (g/bird):** There were significant differences in daily feed intake among the types of processing methods. The results showed that processed and raw Sorrel Seed Meal (SSM) had no adverse effect on feed intake. The value for feed intake observed in this study compared favourably with the report of Olomu (1995) who stated that feed intake should be up to 160 g/bird/day. The difference in the feed intake could be attributed to the elevated ambient temperature of the study environment which ranged between 15-19°C in January and 33-44°C at other

months (Alaku, 1983) and this is above the comfort zone (24°C) (Siegel, 1978) for broiler chicken or adult fowls beyond which feed intake is bound to be lowered.
Similar results were obtained on daily feed intake at the starter, finisher and combined phase with birds fed on boiled sorrel seed meal exhibiting significantly higher feed intake in three phases of the study. The significant difference among types of different processing methods could be attributed to the effect of the different processing method adopted for the sorrel seed, strain of the birds and environmental temperature.

**Feed conversion ratio:** The Feed Conversion Ratio (FCR) which is the feed consumed per unit weight gain did not differ significantly among the types of processing methods in the finisher and combined phase but there were significant difference among the types of processing methods in the starter phase and the overall means. Since FCR is a measure of the efficiency of the bird to convert feed consumed into meat, the lower the value, the better the feed efficiency. The birds fed on boiled sorrel seed meal showed improved feed efficiency compared to the other processing methods. This could be as a result of humid or moist heat treatment recommended by Price *et al.* (1979) as ways of eliminating anti-nutritional factors in feed stuff. This is in line with some results which indicated that birds' amino acid requirement differ depending on the performance responses evaluated. Finishing broilers grown from 1.8-2.6 kg require about 0.72% of sulphur amino acid to optimize feed conversion efficiency (Yalcin *et al.*, 1999). Abasiekong and Tyopat (2000) recommended 2.4% of combined supplementation of both lysine and methionine for optimum performance in broiler chickens. This may account for similar FCR recorded in the study since the levels of the amino acid in test materials were similar (Table 2).

**Economic performance:** The mean final weights of the birds fed on different types of processing methods were significantly different from each other. The feed cost (N/kg) indicated no significant difference among the types of different processing methods. Thus, there was no increase in feed cost as a result of the processing method, because the percentage of the sorrel seed meal of the raw and differently processed method are equal (25%) each. The feed cost per kg gain showed significant difference in favour of birds fed on boiled sorrel seed meal among the types of different processing methods in the three phases of the study. The result obtained in this study is ideal in broiler chicken diets as unconventional plant protein sources drastically reduced feed cost (N/kg) and these gave better returns in terms of cost per kg gain reported by Smith *et al.* (1981).

**Mortality:** The highest mortality of 7.5% was recorded in birds fed on raw sorrel seed meal, followed by 5% in boiled sorrel seed meal and the least was 2.5% in roasted and soaked sorrel seed meal accordingly. Mortality was recorded at weeks 8 and 9 and the highest rate was in week 9. The death coincided with the time of high environmental temperature and the postmortem result showed that the birds died of heat prostration. There was no evidence of any diseases in all the types of different processing methods throughout the experimental period. The result obtained from this study was in line with the report of McDouglad and Malquision (1980) who stated that losses due to heat stress could be substantial during prolonged period of hot weather (heat stress), particularly with birds over 4 weeks of age. Also, Ubosi (1986), stated that mortality is usually high in the sub-sahelian zone of Nigeria during the hot season and that some poultry farmers prefer closing down to staying in business because of the high mortality they encounter during the period.

**Nutrient digestibility:** The result of the apparent digestibility of nutrients showed significant differences ($p<0.05$) among treatments. There seemed to be a numerical increase in values for all nutrients except for crude fibre. This is similar to the report of Nwokolo *et al.* (1985) and Njidda *et al.* (2006) that crude fibre and phytic acid found in most plant do not only resist digestibility by monogastric endogenous enzymes but are also the two common organic compounds known to sequester feed nutrients, rendering them unavailable for animal use.

**Carcass characteristics:** The result showed significant differences in carcass weight, drumstick, thighs, wings and breast muscle weight among the different processing methods.
Birds on boiled sorrel seed meal had significantly better carcass characteristics compared to the other processing methods. This observation on carcass yield agreed with the data on carcass yields of 65-67% (Deschepper and Degroote, 1995) and 65-70% (Oluyemi and Roberts, 1988).
The weight of the cut-up parts drumstick, thighs, wings and breast muscle indicated significant differences in birds fed on boiled sorrel seed meal, but the weight of the cut-up parts did not agree with the yield of cut-up pieces of broilers reported by Oluyemi and Roberts (1988) who reported values of 11.67, 12.95, 8.21 and 17.40 weights for the drumstick, thighs, wings and breast muscle respectively.
The results on carcass characteristics in this study revealed the effect of processing method by Price *et al.* (1979), that humid or moist heat treatment eliminates anti-nutritional factors in feedstuff.

**Conclusion:** The results obtained from the series of experiments in this study indicated that: Sorrel seed meal could serve as a useful feed ingredient for poultry diets. Sorrel seed meal could serve to replace soyabean meal and groundnut cake at up to 60% replacement level and 20% inclusion level in broiler and cockerels diet respectively, due to the similarities in their nutrient and amino acid composition, though sorrel seed meal has higher fibre level. The major anti-nutritional factors identified in the sorrel seed meal are tannins which are known to impair feed intake, nutrient digestibility and growth of poultry and young animals. Boiling as a processing method appears to be a more effective method of tannins reduction in sorrel seed than roasting and soaking in water. Better economic benefits was obtained at 60% level of replacements of soyabean meal and groundnut cake by sorrel seed meal and 20% inclusion level of sorrel seed meal without compromising the biological performance or the health condition of the chickens.

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