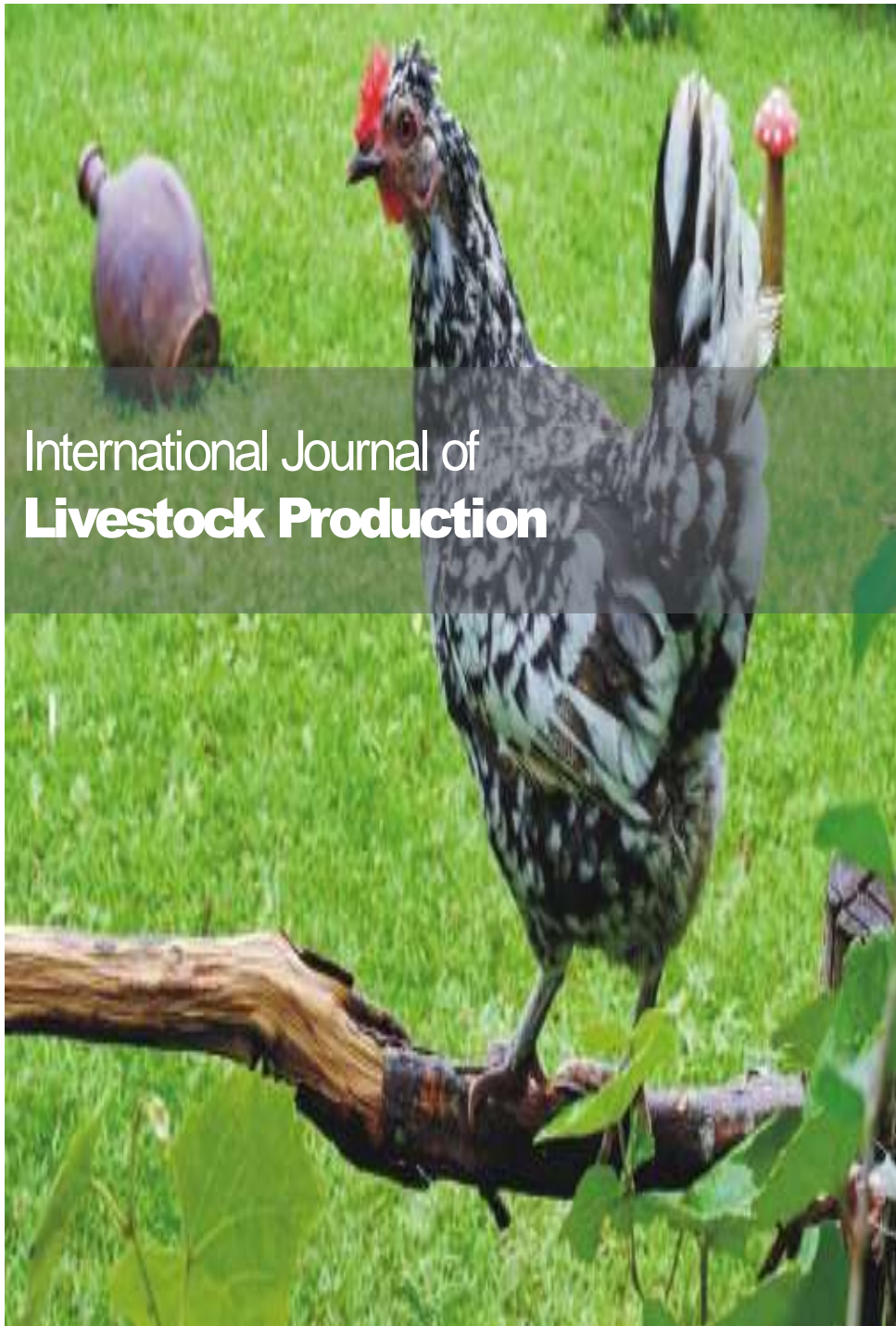


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*Full Length Research Paper*

# Effect of cowpea (*Vigna unguiculata*) grain on growth performance of Cobb 500 broiler chickens

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A total of 300 day old Cobb and 500 broiler chicks distributed randomly to 20 pens with 15 chicks each were allocated to 5 different dietary treatments with 4 replicates per treatment in order to evaluate the growth performances of Cobb 500 broiler chickens. A complete randomized design (CRD) was used. Cowpea inclusion levels were 0% (T1), 5% (T2), 10% (T3), 15% (T4) and 20% (T5). A partial budget analysis was done for the treatments. The results of the study revealed that crude protein, dry matter (DM) and the metabolisable energy content of cowpea grain were 25.76%, 89.94% and 3307.37 kcal/kg DM, respectively. Feed intake did not differ significantly ( $P>0.05$ ) between treatments or inclusion levels. Starter phase ranged from 44 to 45.16 g/bird/day; finisher phase ranged from 113.9 to 117.20 g/bird/day; and the complete experimental period ranged from 83.78 to 85.88 g/bird/day. Daily body weight gains for the entire experimental period were 34.82, 34.27, 36.81, 35.74 and 33.08g (SEM=0.46) for T1, T2, T3, T4 and T5 respectively. There was no significant ( $P>0.05$ ) difference in growth performance for the complete experimental period. Mortality was at 5% for treatment T1 and T4, while for T2, T3, and T5, respectively, no mortality occurred. Partial budget analysis of the different treatments was calculated based on changes in total return. Change in total return was greater in T3 followed by T5, T4, T2 and marginal rate of return was greater in T3 (32.96) than in T2 (5.62), T5 (3.42) and T4 (2.4). This study indicate that inclusion of cowpea from 5 to 20% in the diet of broiler chickens have no adverse effect on growth performance and from the point of partial budget analysis, T3 (10% inclusion level) was the most profitable.

**Key words:** Broiler, cowpea, inclusion level, performance, partial budget analysis.

## INTRODUCTION

Ethiopia has an estimation of 51.35 million chickens with the indigenous chicken of non-descriptive breeds accounting for 96.9%; hybrid chicken, 0.54%; and exotic breeds, 2.56% that are distributed in different agro-ecological zones of the country (CSA, 2013). Their

distribution indicates their adaptive potential to different environmental conditions, diseases and other stresses (Halima, 2007). Rural household poultry is an affordable source of animal protein and family incomes.

In addition, poultry production plays a major role in

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bridging the protein gap in developing countries where the average daily consumption is far below recommended standards (Onyimanyi et al., 2009). Studies have shown that the Cobb 500 broiler chickens are more economically efficient due to their high growth potential, slaughter trait and roasting weight (Hristakieva et al., 2014). However, the productivity of poultry in the tropics has been limited by scarcity and consequent high prices of the conventional protein and energy sources. Protein sources are limiting factors in poultry feed production especially in the tropics (Atawodi et al., 2008). A potential source of proteins for poultry is legume seeds. A protein that contains a high level of lysine and a low level of methionine (Akanji et al., 2012) characterizes them. Many locally available sources of protein and energy, like grain legumes, contribute to the dietary supply of poultry industry in Africa (Akanji et al., 2012). Soybean meal and other oil crop byproducts, like noug cake, are also major sources of protein in poultry diets. However, inadequate production and specific location make them expensive and not easily accessible. An important mitigation strategy to alleviate such problems is the use of alternative sources of protein like cowpea (*Vigna unguiculata*). Cowpea varieties are temperature and drought tolerant crops require low input costs and are well adapted to the arid and semi-arid agro-ecologies. Cowpea, as well as other legumes (such as peas, lentil seeds), can be an excellent source of dietary protein in animal nutrition (Igbasan and Guenter, 1997; Ciurescu et al., 2017; Ciurescu and Pana, 2017). The nutrient and energy concentration of cowpea varieties compared with those of soybean varieties, with similar amino acid content (Ravindran and Blair, 1992) are often less expensive.

The cultivation of this legume is practiced in Tigray National Regional State since long time and it was used as feed source for animals. Intercropping this legume with maize and sorghum improves soil fertility as well as increases productivity and striga control (Dwivedi et al., 2015; Matusso et al., 2014; Fasil and Verkleij, 2007). Many legume varieties, which are used as sources for human food and animal feed, were not studied and properly documented. As an indicator of its suitability in the region, recently, a new variety of cowpea has been released from Humera Agricultural Research Center. The average grain yield of this genotype was 30.6 quintals per ha in three consecutive years (Solomon and Kibrom, 2014). This variety also adapt in the central zone of Tigray and its performances was very promising. It may be used as a potential alternative source of feed that can be incorporated into the poultry diets in order to reduce the high cost of conventional protein sources (Nworgu and Fasogbon, 2007; Iheukwumere et al., 2008). This cultivar of cowpea (Temesgen) is better in its performance when compared with the local legumes such as pigeon pea, which are produced in the region. Moreover, a good source of protein, which is soybean, is

not produced in the Tigray National Regional State. On the other side, the small scale poultry production has increased from time to time. In this case, feed sources are a major challenge in the small-scale poultry production in the region, especial in central zone of Tigray. Hence, this study is designed to assess the recently introduced cowpea (*Vigna unguiculata*) variety in the region as a source of protein for poultry diets, to evaluate its effect on growth performance of Cobb 500 broiler chickens and to analyze the partial cost benefit of feeding cowpea grain as a source of protein.

## MATERIALS AND METHODS

### Description of the study area

The study was carried out in Axum town, central zone of Tigray National Regional State, Northern Ethiopia. Standard protocol approved by the research center for animal care and welfare was followed during sample collection.

### Experimental feed ingredients and treatments

The feed ingredients used in the formulation of the different experimental rations for the study were corn grain, wheat middling, noug seed cakes (NSC), soybean meal (SBM), cowpea grain (CG), vitamin premix, salt, limestone, di-calcium phosphate, L-lysine and D-methionine. All the ingredients, except for SBM, wheat middling, vitamin premix, salt, limestone, dicalcium phosphate, L-lysine and d-methionine, were also milled in a 5 mm sieve size.

Treatments were: T<sub>1</sub>, 0% CG; T<sub>2</sub>, 5% CG; T<sub>3</sub>, 10% CG; T<sub>4</sub>, 15% CG and T<sub>5</sub>, 20% CG. The diets were formulated to be isocaloric and isonitrogenous with metabolizable energy (ME) content: 3000 kcal ME per kg DM and 22% CP for the starter phase (0 to 21 days of age) and 3200 kcal per kg DM and 20% CP for the finisher phase (22 to 49 days of age) by using a feed win software.

### Management of birds and experimental design

Three hundred unsexed Cobb 500 broiler chickens were randomly assigned to five dietary treatments with four replications per treatment in a complete randomized design with 15 chicks per replicate or pen. The pens were prepared by using Eucalyptus (a local material) and wire mesh (industrial material), size 3/1.5 m, with the assumption of required space for the finisher phase. Birds were vaccinated against Newcastle (HB1 at day 7 at an eye drop, LaSota at day 21 in drinking water) and Infectious Bursal Disease (Gumboro) at the age of 14 and 28 days, with the drinking water. Before the commencement of the actual experiment, the experimental pens were cleaned and disinfected 14 days before the arrival of the chicks, using disinfectants and fumigated by using formaldehyde solution and calcium phosphate powder. Watering and feeding troughs were thoroughly prepared and cleaned 24 h before the arrival of the chicks. The temperature of the shelter was adjusted to the desired temperature and humidity, using thermo-hydrometer and digital room temperature 12 h before the arrival of the chicks. Immediately after arrival, the chicks were brooded using 250 watt infrared electric bulbs with gradual height adjustment as sources of heat and light. The floor with deep litter was covered with Teff straw mixed with the sawdust. Clean water and feed were offered ad libitum throughout the experiment.

### Measurements and data collection

The amount of feed offered and refused was recorded daily in order to calculate the feed consumption. The given feed and refusals were sampled daily for each pen and pooled per treatment for the entire experimental period for chemical analysis. Birds were weighed weekly in a group per pen and pen average was calculated. Body weight (BW) change was calculated as the difference between the final and initial BW. Average daily gain (ADG) was calculated as BW change divided by the number of experimental days. Feed conversion ratio (FCR) was computed as the ratio of average daily feed intake to ADG. Mortality was recorded as it occurred and calculated as %age.

### Laboratory analysis

Feed ingredients of the formulated diets and samples of feed offered and refused from the respective treatments were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash (AOAC, 1995). Calcium and total phosphorus content were also determined by atomic absorption and vanadomolybdate method, respectively (AOAC, 1998). Metabolizable energy (ME) content of the experimental diets was determined according to Wiseman (1987) as  $ME \text{ (kcal/kg DM)} = 3951 + 54.4EE - 88.7CF - 40.80 \text{ Ash}$ . Chemical analyses were conducted at Jije laboclass and Ethiopian public health institute Addis Ababa.

### Data analysis

Data were analyzed using the general linear model (GLM) procedures of Statistical Analysis Systems software (SAS, 2002) with the model containing treatments. One-way Analysis of variance (ANOVA) was used to compare the treatment means of the groups and for the existence of significant differences among treatments; the differences between treatment means was separated using Tukey Kramer test at  $P < 0.05$  significance level.

The following model was used for the experiment (Gomez and Gomez, 1984):

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where,  $Y_{ij}$  = Overall Responses,  $\mu$  = overall mean,  $T_i$  =  $i^{\text{th}}$  treatment effect of feeding level and  $e_{ij}$  = random error effect.

### Partial budget analysis

To estimate the economic benefit of cowpea grain level inclusion mixed with maize, noug seed cake, wheat middling and soybean, the partial budget was analysed by considering the feed expense and chicken price according to the principle developed by Upton (1979). The chicks cost, feed cost, labor cost, electric cost, water expense, vaccine expense and bedding material's expense were measured. Profit obtained from the sale of finished broiler chickens after completion of the experiment was estimated based on the differences between gain and losses for the proposed change. The net income (NI) was calculated by subtracting total variable cost (TVC) from total return.

$$NI = TR - TVC$$

The change in net income ( $\Delta NI$ ) was calculated as the difference between the changes in total return and total variable cost ( $\Delta TVC$ ),

$$\Delta NI = \Delta TR - \Delta TVC$$

The marginal rate of return (MRR) was analyzed by considering the changes in return and total variable cost and it was measured the increased in net income ( $\Delta NI$ ) associated with each additional unit of expenditure ( $\Delta TVC$ )

$$MRR = \Delta NI / \Delta TVC$$

Chicks sale cost to feed cost ratio was also calculated as additional parameter to evaluate the efficiency of the change in the feed ingredients. Feed cost per live weight gain was calculated as follows as an indicator of cost and biological efficiency:

$$\text{Feed cost per weight gain} = \frac{\text{Cost of feed consumed (Birr)}}{\text{Live weight gain (kg)}}$$

## RESULTS AND DISCUSSION

### Chemical composition of feed ingredients

The results of laboratory analysis for the different feed ingredients and formulated experimental diets are shown in Table 1. Cowpea grain contained 25.76% CP and 89.94% DM, 6.22% CF, 1.65% EE, 4.6% ash, 3307.37 kcal/kg DM ME, 0.75 g/kg DM tannin and 1.5 g/kg DM phytate. This makes the cowpea grain a good source of protein and energy for poultry production, which can contribute towards overcoming the predicted protein content. Chemical composition of cowpea seed might differ mainly due to variety, treatments and environmental factor. Cowpea, like other legume, contributes to the level of dietary protein in starchy tuber-based diets through their relatively high protein contents, and their quality by forming complementary mixtures with cereals.

The result of chemical analysis of cowpea grain in the current experiment was in line with the finding of Henshaw (2008), Tshovhote et al. (2003) who found that the protein content ranged from 25.35 to 26.43% and the DM content was of 90.7, 90.2 and 90.15% respectively for three cowpea cultivars (Glenda, Agrinawa and Indigenous cowpea). The same researchers reported that the CF content of the same three cultivars ranged from 5.15 to 5.81%. Muamer et al. (2012) also reported that the raw cowpea contain 24.78, 93.66, 0.91, 3.46 and 3.33%, and 3153 kcal/kg DM for CP, DM, EE, CF, Ash and ME, respectively. Except for the DM content, all the other chemical parameters were below the current results. In addition to this, the current proximate composition results were within the range of other authors' result who worked on different varieties of cowpea seeds (Otitoju, 2015; Balaiel, 2014; Agbogidi and Egho, 2012; Tresina and Ramasamy, 2011) and greater than those reported by Abdelatif and El-Jasser (2011). Generally, cowpea genotypes are highly flexible for seed protein and its soluble fraction contents (Noubissié et al., 2011). The same researcher found a variation of CP from 20.79 to 31.78% among different varieties of cowpea seeds. The similarities and the difference of chemical composition between cowpea in this experiment and other reports might be due to variety differences.



**Table 1.** Chemical composition of feed ingredients used to formulate the experimental ration.

Nutrients	Feed Ingredients				
	Maize grain	Noug seed cake	Wheat middling	Cowpea grain	Soybean meal
DM (%)	90.69	92.86	91.15	89.94	94.17
CP (% DM)	8.46	32.26	16.89	25.76	40.04
CF (% DM)	3.45	17.51	8.15	6.22	6.14
EE (% DM)	3.9	7.14	4.77	1.65	10.8
Ash (% DM)	3.28	9	4.36	4.6	5.5
ME(Kcal/kg DM)	3223.65	2419.08	3309.7	3307.37	3769.5
Ca (% DM)	0.04	0.33	0.27	0.15	0.61
P (% DM)	0.46	0.67	1	0.5	0.68
Tannin (g/kg DM)				0.75	
Phytate (g/kg DM)				1.5	

DM = dry matter, CP = crude protein, CF = crude fiber, EE = ether extract, ME = metabolizable energy, Ca = calcium and P = phosphorus.

**Table 2.** Proportion of ingredients used in formulation of broiler starter and finisher diets.

Ingredients	Treatments									
	Starter					Finisher				
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
Maize	33	31	29.5	29	29	46	43.2	42.3	41	40
Noug seed cake	28.1	27	26.5	26.5	26.2	22.6	22.4	21.6	20	18.6
Wheat middling	21.5	21.5	20.7	18.1	15	14.4	14	13	11.6	10.6
Cowpea grain	0	5	10	15	20	0	5	10	15	20
Soybean meal	13	11.2	9	7	5.5	13	11.4	9.2	8.5	7
Dicalcium phosphate	1	0.9	0.9	1	0.9	0.8	1	1	1	1
Limestone	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.5	0.5	0.5
Vitamin premix	1	1	1	1	1	1	1	1	1	1
L-lysine	1	1	1	1	1	0.8	0.7	0.6	0.6	0.5
D-methionine	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100	100	100	100

Based on the above nutritional content of the feed ingredients the starter and finisher diets were prepared as shown in Table 2. These formulations were prepared based on NRC (1994) recommendation required for broiler chickens on both starter and finisher phase.

The analyzed values of each formulated diet is presented as follows in Table 3, for both starter and finisher phase of Cobb 500 broiler chickens fed different levels of Cowpea grain.

Feed consumption, Feed intake and feed conversion ratio of Cobb 500 broiler chickens fed diets with different inclusion levels of cowpea grain during experimental period are presented in Table 4. The whole feed consumption and average daily feed intake on the bases of DM during the starter phase, finisher phase and the

whole experimental period was not influenced ( $P>0.05$ ) by the different treatments when compared with control (T<sub>1</sub>). Inclusion of cowpea grain up to 20% in the diet of broiler did not have a significant impact on feed intake of Cobb 500 broiler chickens. The current results were in line with findings of Eljack et al. (2010) who found that an inclusion of 0, 10, 20 and 30% cowpea grain had no significant effect on feed consumption at starter phase, finisher phase and whole experimental period. Chakam et al. (2010) also found that the inclusion of cooked cowpea (0, 15, 20, 25 and 30%) into the diets of finisher male Hubbard broiler chickens had no significant effect in terms of feed consumption. On the other hand, increasing the level of inclusion of untreated cowpea seed into the diet of broiler chickens showed a significant reduction in

**Table 3.** Chemical composition of the starter and finisher diets of Cobb 500 broiler chickens

Chemical composition	Treatments									
	Starter					Finisher				
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
DM	92.21	92.07	91.94	91.83	91.71	92.02	91.92	91.78	91.67	91.54
CP	21.87	21.91	21.9	21.9	21.97	19.75	19.93	19.74	19.89	19.78
CF	8.61	8.55	8.52	8.48	8.39	7.52	7.56	7.49	7.32	7.17
EE	5.72	5.45	5.16	4.89	4.64	5.5	5.26	4.97	4.74	4.75
Ash	5.26	5.23	5.21	5.2	5.19	4.89	4.9	4.86	4.81	4.75
ME(Kcal/kg DM)	3070	3072	3061	3046	3045	3195	3174	3169	3179	3184
Ca	1.05	1.02	1.01	1.02	0.99	1.01	1.02	1	1	0.99
P	0.82	0.8	0.79	0.79	0.76	0.74	0.77	0.76	0.75	0.74

**Table 4.** Feed intake and feed conversion ratio of Cobb500 broiler chickens.

Nutrients	Treatments					SEM
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
<b>Starter phase</b>						
Feed intake (g/bird)	947.03	946.1	943.18	928.45	923.8	6.37
Feed intake(g/bird/day)	45.18	45.05	44.9	44.2	44	0.31
<b>Finisher phase</b>						
Feed intake (g/bird)	3278	3238	3233	3281	3188	11.61
Feed intake(g/bird/day)	117.08	115.65	115.49	117.2	113.9	0.45
<b>Whole experimental period</b>						
Feed intake (g/bird)	4224	4178	4200	4208	4105	15.41
Feed intake(g/bird/day)	86.22	85.38	85.7	85.88	83.75	0.32

T<sub>1</sub>= 0% inclusion of cowpea grain, T<sub>2</sub>= 5% inclusion of cowpea grain, T<sub>3</sub>= 10% inclusion of cowpea grain, T<sub>4</sub>= 15% inclusion of cowpea grain, T<sub>5</sub>= 20% inclusion of cowpea grain and SEM= Standard Error of Mean.

feed intake (Balaiel, 2014) due to an increased residual effect of anti-nutritional factors found in cowpea grain.

### Growth performance

The growth performance of Cobb 500 broiler chickens fed different levels of cowpea grain inclusion is shown in Table 5. In this experiment there was a significant difference ( $P < 0.05$ ) on final body weight gain and average daily weight gain in starter phase. T<sub>3</sub> and T<sub>4</sub> were greater than T<sub>1</sub>, while values for T<sub>2</sub> and T<sub>5</sub> were similar with T<sub>1</sub>, T<sub>3</sub> and T<sub>4</sub>. At finisher phase, initial weight of T<sub>3</sub> and T<sub>4</sub> was significantly ( $P < 0.05$ ) higher compared to T<sub>1</sub>, whereas average daily weight gain was significantly ( $P < 0.05$ ) in T<sub>3</sub> which was greater than T<sub>5</sub>, while values for T<sub>1</sub>, T<sub>2</sub> and T<sub>4</sub> were similar with T<sub>3</sub> and T<sub>5</sub>. Final body weight gains in finisher phase were not significant ( $P > 0.05$ ) among treatments. There was no significant

( $P > 0.05$ ) difference in final body weight gain and average daily weight gain in the complete experimental period in all treatments. The difference in the starter might be due to slight differences in crude fiber of the ingredient formulated the diet; while, reduction in daily weight gain on T<sub>5</sub> of finisher phase might be related to increased levels of cowpea inclusion in the diet. This might relate to the nature of legume seeds contain anti-nutritional factors which reduces the utilization of proteins and palatability of diets.

The current result was in line with Adebisi et al. (2008) who found that supplementing broiler chickens diets with fungi degraded cowpea seed hulls had no significant effect in weight gain of broiler. At 49 days of age, body weight gain of Cobb 500 broiler chickens among treatments ranged from 1621.13 g to 1803.85 g in the present study which was less than the weight gain of 2599 g and 2435 g reported for Cobb 500 and Ross 308 broiler chickens, respectively (Hristakieva et al., 2014).

**Table 5.** Body weight change of Cobb500 broilers chickens.

Parameter	Treatments					SEM
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>	
<b>Starter phase</b>						
Initial weight (g/bird)	39.75	39.75	40.25	40	39.75	0.22
Final weight (g/bird)	461.38 <sup>b</sup>	472.3 <sup>ab</sup>	517.58 <sup>a</sup>	513.20 <sup>a</sup>	506.53 <sup>ab</sup>	6.97
ADWG(g/bird/day)	21.08 <sup>b</sup>	21.63 <sup>ab</sup>	23.9 <sup>a</sup>	23.7 <sup>a</sup>	23.3 <sup>ab</sup>	0.35
FCR(g feed/g of gain)	2.25	2.20	1.98	1.97	1.98	0.041
<b>Finisher phase</b>						
Initial weight (g/bird)	461.38 <sup>b</sup>	472.3 <sup>ab</sup>	517.58 <sup>a</sup>	513.20 <sup>a</sup>	506.53 <sup>ab</sup>	6.97
Final weight (g/bird)	1666.43	1639.28	1763.55	1711	1581.38	22.37
ADWG(g/bird/day)	44.46 <sup>ab</sup>	43.10 <sup>ab</sup>	45.90 <sup>a</sup>	44.21 <sup>ab</sup>	39.80 <sup>b</sup>	0.7
FCR(g feed/g of gain)	2.65	2.67	2.52	2.65	2.87	0.039
<b>Whole experiment</b>						
Initial weight(g/bird)	39.75	39.75	40.25	40	39.75	0.22
Final weight (g/bird)	1706.18	1679.03	1803.85	1821	1621.13	22.43
ADWG(g/bird/day)	34.82	34.27	36.81	35.74	33.08	0.46
FCR(g feed/g of gain)	2.49	2.49	2.33	2.4	2.54	0.029

<sup>ab</sup> Means within a row and within treatment or sex with different superscripts differ significantly ( $P < 0.05$ ), g=gram; ADWG= Average Daily Weight Gain; T<sub>1</sub>= 0% inclusion of cowpea grain; T<sub>2</sub>= 5% inclusion of cowpea grain; T<sub>3</sub>= 10% inclusion of cowpea grain; T<sub>4</sub>= 15% inclusion of cowpea grain; T<sub>5</sub>= 20% inclusion of cowpea grain, SEM= Standard Error of Mean.

The current results showed that for the complete experimental period, there was no statistical difference between treatments; whereas, Eljack et al. (2010) found that as the inclusion level of cowpea increased the growth performance increased also. On the other hand inclusion of 15% untreated cowpea seed and 20% raw and dehulled, dehulled roasted cowpea, grain of broiler chickens recorded a significant ( $P < 0.05$ ) reduction on growth performance as compared with control and dehulled cooked cowpea (Akanji et al., 2015; Balaiel, 2014). Differences might be due to diet formulation ingredients, environmental factors, difference of cowpea seed variety and treatment used to reduce anti-nutritional factors. Any variation in the environment surrounding the birds resulted in stunted growth and major production losses (Czarick and Fairchild, 2012; Blackely et al., 2007).

### Mortality

The inclusion of different levels of cowpea grain did not show significant difference in mortality rate on T<sub>2</sub>, T<sub>3</sub> and T<sub>5</sub>, respectively. There was a sudden death syndrome of chickens on T<sub>1</sub> and T<sub>4</sub>. In both treatments 5% mortality rate occurred at finisher phase. The phenomenon of lameness occurred in all treatments, T<sub>1</sub>, T<sub>2</sub>, T<sub>3</sub>, T<sub>4</sub> and T<sub>5</sub>, which was 15, 11.67, 10, 13.33 and 15 %, respectively. Lameness in broiler chickens occurred in relation to lack

of the micro mineral (Na<sup>+</sup>, K<sup>+</sup> and Cl<sup>-</sup>) in the diet, due to unbalanced growth of muscle and bone. In this case due to genetic selection meat chickens are fast growing, as a result, they deposit large amount of muscle which is above the capacity of the bone. Finally lameness has occurred as a major problem in broiler production. In the most recent large-scale broiler production studied in the United Kingdom 27.7 % of the birds assessed closed to slaughter age (40 days) showed poor locomotion, and 3.3% were also unable to walk (Knowles et al., 2008). Other authors also reported that, selection for faster and short fattening period leads to an increase of skeletal disorders, which are related to transient difficulty during the phase of fast growth of long bones, especially tibia, since the proximal tibia is the site of the most fast growing growth plate (Angel, 2007).

### Partial budget analysis

Partial budget analysis for Cobb 500 broiler chickens fed different levels of inclusion of cowpea grain is presented in Table 6. The net income was determined depending on the cost of the feed consumed by each bird, chicks cost, labor cost and vaccine expenses, cost of bedding materials, cost of water and electricity. The greater net income per treatment was shown in T<sub>3</sub> followed by T<sub>5</sub>, T<sub>4</sub> and T<sub>2</sub> respectively. Change in net income per treatment ( $\Delta$ NI) showed that T<sub>3</sub> was highest, followed by T<sub>5</sub>, T<sub>2</sub>

**Table 6.** Partial budget analysis for Cobb 500 broiler chickens fed different levels of inclusion of cowpea grain.

Variables	Treatments				
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
Total return/ treatment	5815.14	6100.20	6259.8	5966.19	6060
Net income/treatment	2039.562	2281.56	2498.16	2297.862	2385.36
ΔTR/ treatment	----	285.06	444.66	151.05	244.86
ΔNI/ treatment	----	241.998	458.598	258.30	345.798
ΔTVC/ treatment	----	43.062	-13.938	-107.25	-100.94
MRR	----	5.62	32.90	2.40	3.42
Cost of feed(ETB)/LWG(kg)	23.35	23.1	20.97	20.86	22.44

ETB= Ethiopian Birr; ΔTR= Change in Total Return; ΔNI= Net Income; ΔTVC= Change in Total Variance; MRR= Marginal Rate of Return; T<sub>1</sub>= 0% inclusion of cowpea grain; T<sub>2</sub>= 5% inclusion of cowpea grain; T<sub>3</sub>= 10% inclusion of cowpea grain; T<sub>4</sub>= 15% inclusion of cowpea grain; T<sub>5</sub>= 20% inclusion of cowpea grain.

and T<sub>4</sub>. The differences in change of net income were due to the difference in feed consumption, selling price of individual chickens and the number of chickens in each treatment that reached to market. The marginal rate of return (MRR) showed that for each additional unit of 1 ETB per treatment cost increment, resulted in additional income of 32.90, 5.62, 3.42 and 2.40 for T<sub>3</sub>, T<sub>2</sub>, T<sub>5</sub> and T<sub>4</sub> respectively. Between treatments, T<sub>3</sub> was the more profitable based on the consideration of change in net income (ΔNI) and marginal rate of return (MRR).

The feed costs per weight gain of Cobb 500 broiler chickens were also calculated as additional parameter to indicate the cost of feed and biological efficiency in which feed cost expended for production of 1 kg body weight. In this experiment, the result showed that T<sub>4</sub> was lower in feed cost per weight gain of chicken followed by T<sub>3</sub>, T<sub>5</sub>, T<sub>2</sub> and T<sub>1</sub>, respectively. This indicated that T<sub>4</sub> was better in terms of feed utilization to produce 1 kg body weight gain followed by T<sub>3</sub>, T<sub>5</sub>, T<sub>2</sub> and T<sub>1</sub>, respectively.

## Conclusion

Based on the current study, it is possible to conclude that inclusion of cowpea grain up to 20% in the diet of broiler chickens do not have any adverse effect on growth performance of broiler chickens. Therefore, levels of inclusion from 5-20% can be used as an alternative protein sources in broiler diets. However, based on the partial budget analysis T<sub>3</sub> (10% inclusion level of cowpea grain) on the diet of broiler chickens was more profitable than the other treatments.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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*Full Length Research Paper*

# **Farmers' perception on sheep production constraints in the communal grazing areas of the Eastern Cape Province, South Africa**

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**The study was conducted to identify farmers' perception and ranking of the most important constraints to sheep production at Sinqumeni administrative area, in Ngcobo local municipality of the Eastern Cape Province, South Africa. Data was collected using semi-structured questionnaire. The results showed that 72.6% of the surveyed farmers were males and 62.5% of the farmers were between the ages of 52-80 years. The most important challenges of sheep production perceived by the farmers were disease and parasites (27%), shortage of feed (16.7%), lack of infrastructure (16%), organized market access (14.7%), lack of water availability (10.1%), high cost of drugs/vaccines (9.8%), stock theft (5.7%) respectively. Thus, there is a need to forge strategic partnership with various stakeholders to control the identified challenges through on-going training of farmers using a demonstration approach rather than an oral presentation, formation of cooperatives to minimise the cost of drugs; and conservation of feed and rain water harvesting in preparation for dry season can be a sustainable way of overcoming the constraints experienced by small-scale sheep producers.**

**Key words:** Constraints, feed, disease, sheep, small-scale.

## **INTRODUCTION**

Sheep farming is mainly subsistence and is characterized by low inputs in the Eastern Cape rural areas. Livestock production in the Eastern Cape Province (ECP), like in most developing countries, is two-dimensional and consists of communal and commercial livestock farming (Braker et al., 2002). The communal farming sector is dominated by resource poor farmers who are rural dwellers. In this sector, there is limited application of the recommended livestock management practices. This could be linked to the low literacy levels of farmers and

the history of livestock keeping practices by the livestock owners; whereas on the other hand, the commercial sector is made up of individual farmers on private property with farming done as a business and the application of best practices is practised in order to make profit. The distribution of grazing land is however skewed as the majority of the land is under the commercial farming sector as compared to the communal farming sector.

South Africa has estimated sheep population of 24,392

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million (National Livestock Statistics, 2012) and 29% of these are raised by communal farmers of the ECP and Free State (CAPEWOOLS South Africa, 2007). In South Africa, there are different breeds of sheep found widely distributed across different agro-ecological zones, where they provide income, quality food (meat) and fertilizer (Haenlein and Ramirez, 2007; Bayer et al., 2001), thus contributing to household livelihood, food security, poverty alleviation (Miao et al., 2005) and nutrition (FAO, 2009). Livestock is also a means of risk avoidance during crop failure and cultural functions during festivals (Kosgey et al., 2008). Although sheep farming is widely distributed in all provinces, the largest number is found in the ECP which is estimated to be 7.056 million (National Livestock Statistics, 2012). The productivity is low considering the large resource available and compared to the commercial sector. Communal sheep farming reflects a high level of mortality ( $\pm 25\%$ ), a low reproduction rate ( $\pm 56\%$ ), a low weaning percentage ( $\pm 45\%$ ) and low turnover (Bembridge, 1989). Various studies indicated that seasonal variation in feed availability, poor management practices, diseases and parasites, stock theft, lack of water availability, poor genetic potential and ineffective marketing are the major causes of the low production in these areas (Kusina and Kusina, 1999; Ben and Smith, 2008; Nsoso and Madimabe, 2003; Karimuribo et al., 2011). These factors contribute to a very low off-take ( $\pm 9.9\%$ ) and poor returns to the cash economy of the province.

Sheep have a great potential to contribute more to the livelihoods of the people in low-input, small-scale mixed crop livestock production systems (Kosgey and Okeyo, 2007). Increase in the current level of productivity of sheep is essential to meet the demands of the ever-increasing human population, to increase household income and to improve export earnings. However, in 2009 the National Department of Agriculture indicated that agriculture contributes around 6.5% to total export earnings.

There is limited knowledge available on the constraints faced by small-scale sheep producers. Therefore, this study was designed to identify the main constraints limiting sheep production in the communal areas of the ECP in order to suggest improvements strategies to policy makers.

## MATERIALS AND METHODS

### Study area

The study was conducted between July 2009 and September 2010 in Sinqumeni Administrative Area in Ngcobo Local Municipality which falls under Chris Hani District Municipality. Facilitation processes were followed in terms of meeting with farmers and community elders, local authorities and local extension officers. Sinqumeni is located 50 km North of Ngcobo town and 35 km East of Ugie town. Sinqumeni is situated within  $31^{\circ} 12' 30''$  S longitude and  $28^{\circ} 13' 45''$  E latitude. The mean annual rainfall was  $\pm 620$  mm.

The vegetation is classified as Drakensberg Foothill Moist Grassland (Mucina and Rutherford, 2006). The most common grass species is *Themeda triandra*.

### Data collection

A semi-structured questionnaire was used to obtain the information. According to Nogantsi (2010), the size of the sample depends on many factors such as budget, administrative concern and time. A total of 62 informants (72.6% males and 27.4% females) were selected purposively with the assistance of extension officer and community elders and local authorities, based on their willingness to participate and have experience farming and own livestock. Prior to data collection the questionnaire was pre-tested. Each participant was separately interviewed in their vernacular language and later translated to English by the research team from Dohne Agricultural Development Institute. The questionnaire basically covered the household characteristics of sheep farmers, constraints that limited sheep production.

### Statistical analyses

Data collected was captured on Excel and analysed using Statistical Package for Social Science (SPSS, 2000) to generate descriptive statistics.

## RESULTS AND DISCUSSION

From this study, the mean age of respondents was 50.1 years (ranging from 20 to 85 years). The majority (62.5%) of respondents were adults within the age bracket of 52-80 years. Similar findings by Scholtz et al (2008) showed that rural migration of the youth in search for greener pastures contributed to the higher proportion of rural farmers who were 60 years. This was also observed by Katiyatiya et al. (2014) who interviewed farmers that were 51 years of age or older ( $>51$ ). Farming is considered as an alternative for people retiring from their jobs and that the young and active people migrate to urban areas to seek better opportunities, are actively involved in other agricultural enterprises or do not consider farming as a potential business.

Men owned more livestock (72.6%) as compared to women (27.4%). This is in agreement with the findings of Mapiliyao et al. (2012) and Kunene and Fossey (2006) who concluded that livestock farming is a male dominated business. Similar findings were also observed in Nigeria and Tanzania by Kristjanson et al. (2010) and Covarrubias et al. (2012) where men dominated the livestock industry in rural areas. The lower proportion of female farmers could be due to the inability to get their own farmland as head of a family if they are not married. In addition to this, there are other responsibilities for women that may not be associated with livestock production such as household duties (Musemwa et al., 2010; Fayemi and Muchenje, 2013). This is in contrast to a previous study by Anaeto et al. (2009) where women owned more sheep (70%) than men (30%) in Ogun State, Nigeria. Similar to this, Modise (2004) reported that more

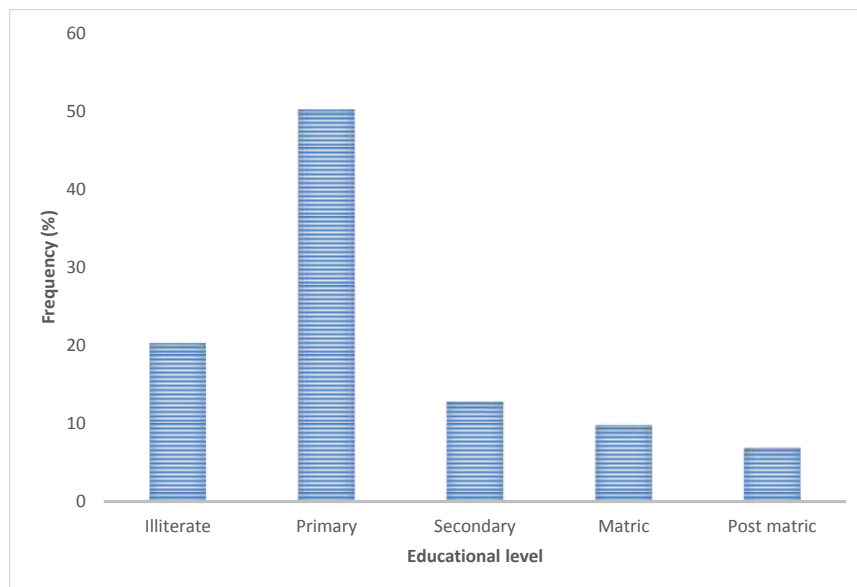


Figure 1. Educational level of the respondents.

Table 1. Demographic characteristics of respondents.

Gender	Age (years)		Household size	
	No.	%	Category	%
Male	45	72.6	<40	27.5
Female	17	27.4	41-60	42.5
			>61	30.0
			<5	32.5
			6-10	47.4
			>11	20.1

women (84%) participated in poultry farming than men. It was noted that in certain households when the husband passed away, women cannot take ownership of the sheep. The reasons could be due to social and cultural factors as well as a lack of capital.

The mean family size was 4.2 members/household. This size obtained in this survey was higher than the provincial and national average family size of 3.9 and 5.6 respectively (Census, 2011). This finding was similar to that reported by FAO (2010) where the average family size in Vietnam was between 4.0 and 5.2. In general, difference in family size may be attributed to the low level of awareness in family planning in the rural areas. The results also showed that 50.2, 12.8, 9.8, and 6.9% had primary, secondary, matric and post matric education, respectively, whereas the remaining 20.3% of the respondents had no formal education (Figure 1). The high proportion of farmers having primary education is a good indicator of the potential of these farmers to be exposed to new and more advanced management and production programs; for example, record keeping which is of paramount importance for decision making in farming industry.

### Farmers perceived constraints associated with sheep production in the study area

The perceptions of farmers on the constraints associated with sheep production are shown in Table 1. The results show that high prevalence of diseases and parasites (27%), shortage of feed (16.7%), lack of infrastructure (16%), organized market access (14.7%), lack of water availability (10.1%), high cost of drugs/vaccines (9.8%) and stock theft (5.7%) were among the major challenges facing sheep farmers in the study area (Table 2).

### Disease and parasite

High prevalence of diseases and parasites is a serious constraint on small ruminant production particularly in more humid areas. High incident of diseases may cause high mortality among lambs, kids and results to low reproduction performance. Farmers ranked diseases and parasites as major constraints to sheep production in the study area. The reasons for high prevalence of diseases and parasites might be due to high cost of drugs, long



**Table 2.** Major constraints to small-scale sheep production in Sinqumeni.

Constraints	Sinqumeni (n= 62)		
	Frequency	Ranking	%
Shortage of feed	32	4	14.2
Lack of water availability	23	5	10.2
Diseases and parasites	62	1	27.6
Organized market access	40	3	17.8
Stock theft	11	7	4.9
Lack of infrastructure	43	2	19.1
High cost of drugs/vaccines	14	6	6.2
<b>Total</b>	<b>225</b>		<b>100</b>

distance to health care centres and visibility of animal health advisors. These findings are in agreement with Githiori et al. (2006) and Mapiliyao et al. (2012) in sheep. Contrary to our findings, a study conducted by Belay et al. (2013) at Ginchi Watershed area ranked diseases and parasite as second.

### Shortage of feed

In most communal grazing areas, natural veld is the major source of feed for livestock (Mapiye et al., 2009). Report from RMRD SA (2012) confirmed that 70% of agricultural land in South Africa is suitable only for extensive livestock production. Livestock on communal grazing areas depend on low quality roughages during prolonged dry seasons for their nutrient requirements (Becholie et al., 2005). Severe shortage of feed worsened during winter due to seasonal nature of rainfall which leads to fluctuations in forage quantity and quality. Livestock in communal grazing areas is characterized by a low reproductive, high mortality rate, low weaning percentage and severe weight loss (Bembridge, 1989; Devendra, 1990). Shortage of feed was ranked the second; this can be attributed by high livestock number, prolonged drought seasons and construction of homestead in grazing areas due to high human population. The findings confirm the assertions made by Mutibvu et al. (2012), Ben and Smith (2008) and Harding et al. (2007) that the major problems of sheep and cattle rearing include among other things, the shortage of feed. Study conducted by Mapiliyao et al. (2012) at Sompondo and Gaga ranked shortage of feed as the fourth and seventh constraint, respectively.

### Lack of infrastructure and market access

Infrastructure is viewed as one of the key pillars for enterprise profitability. Lack of infrastructure was mentioned as third constraints whereas market access is the fourth constraint. There is link between the two

constraints especially in rural areas where there are no access roads and marketing facilities. The results from the study concurs with the findings of Makhura (2001) and D'Hease and Kirsten (2003) who reported that the smallholder farmers have been neglected in terms of infrastructure support by past government. This conforms to findings by NERPO (2004), Wani et al. (2009), Agholor (2013), Sabapara et al. (2014) and Fikru and Omer (2015), who stated that unavailability of marketing infrastructure facilities such as sale pens, loading, off-loading ramps and access roads were the major constraints to small-scale farmers marketing of livestock in various parts of the world. Lack of infrastructure resulting to poor market access in rural areas will lower the income, increase poverty and hunger. Musemwa et al. (2008) affirmed that marketing constraints such as poor availability of infrastructure likely affects small-scale farmers more than production challenges.

### Shortage/lack of water

The main sources of water in most communal grazing areas are rivers and dams. Farmers ranked shortage of water as fifth constraints. Shortage of water might be due to high stock numbers, expansion of irrigated land for crops, human consumption and household use along with scarcity of rain due to climate change. Similar studies conducted by Charlotte and Manderson (1998) as well as Lukuyu et al. (2009) reported that lack of water is a major problem which results in reduction of feed intake, imposing a limit on milk yield and growth rate.

### High cost of drugs/vaccines

The sixth constraint raised by farmers was high cost of drugs. High cost of drugs/vaccines are the major causes for high mortality rate among sheep producers under small-scale production system. Study conducted by Maingi and Njoroge (2010) and Aphunu et al. (2011) are in agreement where high cost of drugs was among the

major constraints that hampers livestock production.

### Stock theft

Out of all the respondents, 5.5% ranked stock theft as a key challenge for sheep production. High stock theft may be caused by high unemployment rate and quick cash yield. This is similar to the findings of Kabore et al. (2011) and Mashala (2013) for livestock.

### Conclusion

Results of the study show that diseases, shortage of feed, lack of infrastructure, organized market access, lack of water availability, high cost of drugs/vaccines, stock theft, visibility of animal health technicians and extension officers, selection of adapted animals and ewe to ram ratio were the major constraints limiting sheep production. Based on the results of this study, the following recommendations can be made for improving small-scale sheep production in the communal areas. Forging a strategic partnership with various stakeholders to control the identified challenges through on-going training of farmers using a demonstration approach rather than an oral presentation, formation of cooperatives to minimise the cost of drugs, conservation of feed, planting of leguminous and rain water harvesting in preparation for dry season can be a sustainable way of overcoming the constraints experienced by small-scale sheep producers.

### CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

# **A critical audit on available beef and chicken edible offals and their prices in retail chain stores around Gaborone, Botswana**

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**The study aims to determine the available beef and chicken edible offals and their prices in four major retail stores in Gaborone, Botswana. Traditionally, edible beef and chicken offal were available and sold in rural meat and informal markets around Gaborone, but recently upmarket retail stores of Gaborone sell these products. The study was done over a period of twelve months. Amongst the offals noted in the retail stores were ox tail, tongue, spleen, ox heel, kidneys, intestines, rumen, omasum, liver and ox heart for beef and feet, liver, gizzards, intestines, necks and kidneys for chicken. Offals were cheaper than the cheapest standard beef and chicken cuts being the chuck/brisket or stewing beef for beef and breast for chicken. Green beef offals were generally cheaper than red offals. The most expensive beef offal was ox tail at ~P60.00, and the cheapest offal was ox heel at ~P19.95 (USD1.00 ~ BWP11.00). For chicken, the gizzards were the most expensive at ~P49.45, with the necks being the cheapest at ~P26.59. Improved marketing and utilization of offals will reduce meat wastage. Meat processors will consequently generate more income, and assist with food security and nutrition at household level.**

**Key words:** Beef, chicken, edible offal products, pricing, retail chain stores.

## **INTRODUCTION**

Beef and poultry production is a major livestock industry in Botswana. The country is self-sufficient in chicken production, and it exports excess beef to European countries (FAO and Ministry of Agriculture, 2013; Sharma, 2014). Of all livestock reared in Botswana, almost every family owns chickens, which provide a valuable source of family protein and additional income (Moreki, 2010). Livestock farming provides vital employment opportunities, and it is an important socio-economic and cultural role in the lives of rural communities (FAO and

Ministry of Agriculture, 2013; Mareko and Mpusang, 2011; Sharma, 2014). World population is estimated to reach 9 billion by 2050, and this is associated with an increasing urban population with an estimated 70% being in urban settlements compared to 49% currently (FAO, 2009; Parr et al., 2016). This population increase will further be associated with improved purchasing power, placing an ever increasing strain on food production systems throughout the world, particularly on commodities targeted by high income earners, such as meat (FAO,

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2014; Parr et al., 2016). So to mitigate this ever increasing challenge of food production meant to meet the world's expanding population, FAO estimates that food production should increase by at least 60% from the current rate to meet the global food demands by 2050 (FAO, 2014). As part of efforts to increase food production and its efficiencies, priority needs to be given to increasing production and consumption of currently under-utilised and under-appreciated traditional staple foods. Environmental implications, as well as nutritional imbalance in diets will need sustainable livestock production with efficient utilization of each animal slaughtered for human consumption, and efficient utilization of edible by-products such as offals can be among such strategies (Umaraw et al., 2015). Edible offals are consumable parts of an animal that are not skeletal muscle (Marti et al., 2011).

In Botswana, consumption of offals of different meat animals has been part of traditional meat consumption, mainly in rural areas and in informal markets in urban centres. But of late major retail stores in urban areas have these products in their shelves as part of their meat products, Gaborone retail stores included. Locally, no information exists on the distribution, utilization and prices of offals, despite the fact that they have for a long time been part of the traditional meat production and consumption systems. Edible offals also referred to as organ meat are a good source of protein, and some organs, notably the liver and kidney, are rich in vital minerals and carbohydrates (Devatkal et al., 2004; Alao et al., 2017); and in less developed countries like Botswana, they are highly consumed because of tradition and being inexpensive (Ogwok et al., 2014). However, not all offals or their parts are eaten and this depends on consumer acceptance, religion and tradition as well as regulations imposed for reasons of hygiene (Omole et al., 2008). Efficient utilization of offals returns good source of revenue to the meat industries. Once put to good use, carcass by-products can lead to an increase of about 3% utilization of live animal, leading to a direct increase of the saleable value of a meat animal by 6.94% (Umaraw et al., 2015). In a modern set up, price defines the quality of the product but with offals it is generally the opposite, because offals are cheap and still highly nutritious just like lean meat cuts.

Currently, no information is available in Botswana as to what edible offals are in chain stores and at what price. These products are usually sidelined in research although they contribute heavily in terms of nutrition and food security at household level. Apart from them being equally nutritious just like lean tissue meat, offals are reasonably affordable to consumers with low income. The presence of edible offals in upmarket chain stores that are some foreign to Botswana, and revered by city dwellers, has improved their status, availability and consumption in the local meat industry. That is why it is worth characterizing the availability and pricing of these

products. This will give an idea on their role in the local meat industry, food availability, security and nutrition at household level. Therefore, this study aims to systemically characterize the presence and/or available beef and chicken edible offals and their prices in Gaborone's four main retail chain stores.

## MATERIALS AND METHODS

### Study area

The study was carried out in four main retail chain stores around Gaborone, Botswana. Gaborone is a city found in South East, Botswana. It is located at -24.65 latitude and 25.91 longitude and it is situated at elevation of 1011 m above sea level.

### Study design

Four upmarket retail chain stores selling fast moving consumer goods in Gaborone and having beef and chicken offal products in their meat section shelves were used in the study. Data were collected on edible beef and chicken offal products on sale over a twelve months period (January, 2016 -January, 2017). The retail stores were visited twice every week to monitor the presence of the products and their respective prices.

### Data collection and analysis

A data collection sheet with all known edible beef and chicken offals in Botswana was developed for the study. During every visit, a check was indicated on available offals and their prices to properly establish that the retail store does keep and/or sells the offal as a regular sales item. Data presented in this study were only on offal products always found in the retail stores over the study period. The data were cleaned and verified, processed into spreadsheets and analyzed to get average offal prices over the study period. Data evaluated were beef edible offals, being oxtail, tongue, liver, kidneys, ox heart, large tripe, spleen, small tripe, ox casing and ox heels, and necks, feet, liver, kidneys, heart and gizzards as chicken offals. Further, sample pictures of those offals identified as regular sales items in the four stores were taken as part of data collection and for illustration purposes. Information collected on the offal products in shelves included; retail product name and prize per kg (BWP/kg), and anatomical/science names were included in the results as part of illustration. At the end of the study, prices collected at store level over the study period were averaged out per product across the four stores to establish their pricing level relative to standard and cheap beef/chicken cuts. As a reference for offal prices over the period, prices of the cheapest standard cut, being the chuck, brisket or stewing beef at ~P39.95 for beef and breast at ~P58.95 for chicken were used and also averaged over the study period.

## RESULTS AND DISCUSSION

The study confirmed the presence and/ or selling of different edible beef and chicken offals in the four retail stores in Gaborone City. These meat products have commonly been available in rural and or traditional slaughtering processes, and in non-chain butcherries in



**Figure 1.** A Serobe dish (a chopped mixture of intestines/casing and tripe).



**Figure 2.** Some of the beef offal products available in the retail stores.

poor, high density population sections of towns and cities of Botswana. In these parts of the society, edible offals have always provided valuable high quality animal protein, but at a cheaper rate (Pula/kg). Amongst offals identified and sold in the retail stores in this study were; ox tail, tongue, spleen, ox heel, kidneys, intestines, rumen, omasum, liver and ox heart for beef and, feet, liver, gizzards, intestines, necks and kidneys for chicken. Offals were generally cheaper than the cheapest standard beef and chicken cuts being the chuck/brisket or stewing beef for beef and breast for chicken. These products are sold cheaply because in most cases their packaging and presentation is not that appealing to customers. According to Walsh (2014), poor farming and processing practices usually lead to condemnations of many edible by products during meat inspection, and floor waste, thus making these products not to reach the market place. Furthermore, offal material has a short shelf life, hence requiring proper processing, handling and storage (Wong et al., 2011). Once carefully handled, processed and marketed, offals status can be improved. Farmers can also play an important role in improving offal material quality by practicing better herd health and management strategies at farm level. With proper understating of offals' value by farmers, they will be empowered to think of their livestock as a package of products rather than simply a carcass (Stanley, 2009). Generally, the yield of by-products has been reported to account for about 10 to 15% of the value of the live animal in developed countries, although animal by-products account for about two-third of the animal after slaughter (Alao et al., 2017).

Unfortunately, offals in the local stores were barely processed, poorly packaged and presented (Figures 1 and 2). In order to diversity and improve the value and



utilization of edible offals and cover a variety of markets, local meat processors can use different preparation and product combinations. The offals can be offered as fresh, frozen, sliced, smoked, cured and ground (Jayathilakan et al., 2012) (Table 1). They can also be packed ready for boiling or boiled, for braising or braised, for frying or fried, for grilling or grilled, for stewing or stewed, for soups and as meat specialties such as loaves. The processing, storage and preparation for consumption are mainly culture, animal type and dish dependent (Jayathilakan et al., 2012; Omole et al., 2008). Locally, various offal cooking methods are employed too, and these are as per type of animal, culture, tribe and type of the dish and occasion. Most of the offals can either be prepared alone and or in combination. The most common and simple method of preparation is boiling until the portion is deemed done. As reported by Jayathilakan et al. (2012), also in local preparations and the retail stores visited, the preparation includes different cooking methods during the same preparation of the same product or mixture, such as boiling and thereafter, frying (Table 1). In Botswana, traditionally, beef and chicken offals such as liver, spleen, heart, kidneys and intestines are commonly cooked alone, whereas some of these may be combined if sourced from small stock, such as goats and sheep to prepare yet another unique delicacy dish referred to as 'serobe' (Figure 1). As highlighted earlier, the preparation style, cooking method and combinations tend to vary across tribes/regions, culture, religion, occasion and according to animal type and age (Jayathilakan et al., 2012; Liu, 2002; Stanley, 2009; Erasmus and Hoffman, 2017). The serobe dish is common across the Botswana communities and some South African tribes. In South Africa, Black Africans stew animal lining (mala) and stomach lining (mogodu) together to produce a dish referred to as 'Mala mogodu' (Erasmus and Hoffman, 2017).

### Edible beef offals

Beef offals commonly available in the supermarkets were amongst them, oxtail, tongue, liver, kidney, heart, large and small tripe, spleen, ox casing and heels/hooves (Figure 2). These products were common across the four retail stores of Gaborone. But more edible beef offals are available in Botswana. Their utilization is influenced by factors such region, tribe, religion and culture. As reported by Jayathilakan et al. (2012) and Erasmus and Hoffman (2017), other beef edible offals across the world are brains, cheek and head trimmings, ear, skin, fat, blood, bone, lungs, sex organs and udders. The advent of reliable refrigeration systems led to offals becoming an important part of the regular meat industry across the world (Bowater and Crustafson, 1988). But in some parts of the world such as Africa, Asia and Latin America, offals have been part of the meat industry for time immemorial.

The edible by products from slaughtered animals are segregated, chilled, and processed (Bowater and Crustafson, 1988; Marti et al., 2011). These products include livers, hearts, tongues, tails, kidneys, brains, sweetbreads (the thymus and/or pancreas gland, depending on an animal's age), tripe (stomach), melt (spleen), chitterlings and natural casings (intestines), fries (testicles), rinds, head meat, lips, fats and other trimmings, blood, and certain bones (Bowater and Crustafson, 1988; Devatkal et al., 2004; Marti et al., 2011). As detailed in Figure 2, some offals such as ox liver, kidney, tongue, rumen, heart, omasum and spleen as reported earlier, were found available and on sale in the four study stores. Edible byproducts can be categorized into variety of meats or edible fats and oils. These can further be classified as organs and glands; brains, hearts, kidneys, livers, and tongues along with oxtails (Bowater and Crustafson, 1988; Marti et al., 2011). The beef edible offals offered for sale in the four Gaborone stores were spread across the two categories of green and red types. Most of the red offals were more expensive compared to the green type (Table 2). As highlighted by other studies (Bowater and Crustafson, 1988; Marti et al., 2011; Stanley, 2009), even locally, offals contribute to the bottom line of the meat industry as proven by their availability and selling in the visited stores. According to Marti et al. (2011), several factors help to account for the sluggish growth in the value of beef byproducts relative to the value of the whole animal. Among these factors are the physicochemical of the offals, culture, religion and the cost of their recovery. But of late, efficiency gains from technological advances have lowered the costs of recovering byproducts, enabling packers and renderers to sell more byproducts at a lower price and still maintain profitability (Bowater and Crustafson, 1988; Devatkal et al., 2004; Jayathilakan et al., 2012; Marti et al., 2011). Further, these offals are essential in contributing to the local food security and human nutrition.

In agreement with Marti et al. (2011) and Liu (2002), offals in this study were also found to be relatively cheaper and affordable. In the four stores used for this audit, most offals were relatively much cheaper compared to even the most cheap standard meat cut of the chuck or stewing beef that sold at ~P39.95 kg<sup>-1</sup> (Table 2). This study revealed that red offals are generally more expensive compared to green offals. The most expensive offals were the ox tail and tongue at ~P60.00 and P39.95 kg<sup>-1</sup>, respectively. The cheapest offal product was the ox heels at ~P19.95 kg<sup>-1</sup> (Table 2). Although the ox tail is referred as an offal product, locally it is a highly priced product that is mainly purchased by well off members of the society. It is usually sliced into small portions, well packed and used for special dishes in homes and for pricey meals in up-market restaurants. Further, ox tail is traditionally left as part of the priced loin and rump cuts during carcass dressing, that are used for

**Table 1.** General Uses and Preparation of edible offals.

Offal type	Storage and preparation	Way in which it is used
Ox tail	Frozen, fresh or refrigerated	Cooked in salty liquid
Tongue	Frozen, fresh or refrigerated whole	Cooked in liquid, cured, sausage casing, sausage ingredient
Liver/gizzards	Frozen, fresh or refrigerated	Braised, boiled, fried, in loaf, patty and sausage
Kidneys/livers	Whole, sliced or ground, fresh or refrigerated	Boiled, boiled in liquid, braised, in soup, grilled, in stew
Hearts	Whole, sliced, frozen, fresh or refrigerated	Braised, cooked in liquid, luncheon meat, patty, loaf
Large tripe	Fresh, refrigerated, smoked and pickled	Boiled and cooked in liquid, sausage casing, sausage ingredient
Spleen	Fresh, refrigerated and pre-cooked	Fried, in pies, in blood sausage
Intestines	Whole, sliced, frozen, fresh or refrigerated	Boiled and cooked in liquid, sausage casing, sausage ingredient
Ox casing	Whole, sliced, frozen, fresh or refrigerated	Sausage casing
Ox heels/feet	Frozen, refrigerated, fresh	Jelly, pickled, cooked in liquid, fried

Source: Jayathilakan et al. (2012).

**Table 2.** Edible beef offal products and their prices in retail chain stores in Gaborone.

Retail product name	Anatomical name	Product price <sup>a</sup>
Ox tail	Tail	60.00
Tongue	Tongue	39.95
Liver	Liver	33.95
Kidneys	Kidneys	29.95
Ox heart	Heart	27.95
Large tripe	Rumen	26.70
Spleen	Spleen	23.45
Small tripe	Omasum	20.45
Ox casing	Intestines	20.95
Ox heels	Heel	19.95

<sup>a</sup>USD1.00 ~ BWP11.00.

the preparation of the famed delicacy meat dish called 'mokoto', that involves boiling and consequently, shredding of the meat portions mixture before serving. On the other hand, ox heels are mainly cheaper because they tend to contain mostly bones of the lower part of the leg, being the hock, cannon, hoof, dewclaw and the pastern (Bryan, 1993; Bruns, 1997). This makes ox heel not easy to cook too, taking long to get ready to be served since it also consists mainly of cartilage material that needs to be properly cooked, entailing mainly boiling until the material is gelatinous before serving (Jayathilakan et al., 2012) (Table 1).

In agreement with Stanley (2009), at Alliance Group in New Zealand, tongue was more expensive compared to the feet, at £0.74 per tongue and £0.15 each feet. Interestingly, at the LTT Abattoir in Limpopo, South Africa, the heel was more expensive compared to the stomach and liver, at South African rand, R14.95, R13.68 and R12.50, respectively. This South African pricing compared to that of Botswana and New Zealand can be explained to some extent by the differences in packaging methods, cutting methods, cultural preferences and the

composition of the offal product on sale. According to Bowater and Crustafson (1988), to service the local market and provide the edible meat by-products required for local consumption, export operations are a distinct division from local needs in the case of Botswana meat market. Offals going to the local market are normally not trimmed to specification and packed, but rather they are passed directly to a chiller unwrapped. Mostly they are held as offal sets comprising the head complete, the liver, the tail, the heart, the spleen and the kidneys (Bowater and Crustafson, 1988). Chilling will normally take place on trolleys or on special trays, which will be placed in the cold room. Disposal to the local market is then carried out by the butchers bringing their own vans to the meat works and manhandling the offal sets into their vans. This is a totally different approach from export, in that the heads are taken whole by the butcher and are not broken down into tongues, brains, cheek meat, etc., by the meat works (Bowater and Crustafson, 1988).

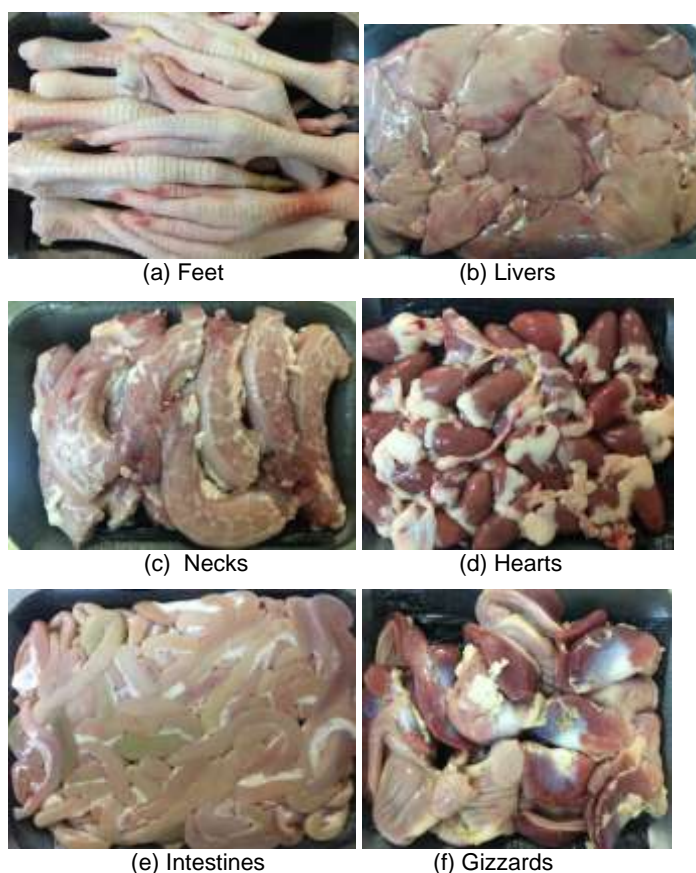
As reported in South Africa by Stanely (2009), where there is a large market for offals, to obtain the highest margins for edible offal it is important to understand the



**Table 3.** Edible chicken offal products and their prices in retail chain stores in Gaborone.

Retail product name	Anatomical name	Product price <sup>a</sup>
Necks	Necks	26.59
Feet	Feet	29.95
Liver	Liver	35.95
Kidneys	Kidneys	38.95
Heart	Hearts	29.70
Gizzards	Gizzards	49.45
Breast	Breast	58.95

<sup>a</sup>USD1.00 ~ BWP11.00



**Figure 3.** Some of the edible chicken offal products available in the retail stores.

culture and need of the target market. Locally too, a large market for offals does exist, and their sale also covers the cost of slaughter and further provides a modest profit to meat traders. Offals represent high value cheap protein in most developing countries, Botswana inclusive. These countries have a very large poor population segment, and offals are a staple to many diets (Stanley, 2009).

As reported by Marti et al. (2011), offals are barely processed and it was the same case even in the current

study. Intestines and cheek meats are usually processed further, often into sausages and other processed meat products (Marti et al., 2011). Offal products deemed too large for packaging or handling were just sliced or cut into smaller pieces, more especially the gastro-intestinal tract material; intestines, omasum and rumen. One other product that was commonly cut or sliced into small portions across the stores was the liver, given that cattle livers are relatively large too. They were also cut into smaller portions to ease handling and purchase decisions by customers.

As reported by Liu (2002), in the traditional setup, beef offals have always been part of diets, but of late, this offal material has been introduced into major city stores even in the case of Botswana. This has made them easily accessible by city dwellers, who are mostly familiar with them from their traditional and/or rural upbringing food systems. These offals, being animal products, although cheaper compared to the standard carcass cuts, they offer consumers the precious and high quality animal based protein food material at an affordable price (Jayathilakan et al., 2012; Liu, 2002; Stanley, 2009). This trait makes offal products prime candidates for assured food security and human nutrition mainly in the developing part of the world where malnutrition is always rife.

### Chicken edible offals

It was evident during the audit that Gaborone supermarkets have also added to their meat product chicken offals, and amongst these were; necks, feet, livers, kidneys, hearts and gizzards (Table 3 and Figure 3). Chicken offals are generally smaller than other meat cuts so they are usually sold and cooked whole without any slicing necessary. Locally, cooking and serving of these offals is simple as most consumers prefer to boil and/or fry them. Different communities prepare chicken offals differently as part of their dishes (Jayathilakan et al., 2012) (Table 1). They are either consumed as snacks or as relish for different porridges. According to Erasmus and Hoffman (2017), in South Africa, the price of fresh

chicken and pork retails roughly 60 and 30%, respectively, lower than that of beef and lamb/mutton, hence, the trend is that consumers will purchase meat that is more cost-effective. In this study, it shows that chicken offals were all relatively cheaper compared to a standard chicken cut, the breast. Necks were the cheapest at ~P26.59, with the gizzards being the most expensive at ~P49.45. It is evident that even the gizzards being most expensive chicken offals, they were still lower in price compared to the breasts. These products, despite being cheaper, still provide impoverished communities and low income earners with valuable animal proteins. Their availability in informal markets thus correlates with and is driven by the low-income consumers (Erasmus and Hoffman, 2017). Therefore, price, together with income, can be seen as important factors for the consumptive traits. These products are nutritionally important. According to Thompson (2015), a 100 g serving of pan-fried chicken liver contains 172 calories, more than 100 of which come from protein. A single serving of chicken liver contains 25.8 g of protein, which provides more than 40% of the daily recommended Intake (DRI) for protein (Thompson, 2015). Chicken liver is a complete protein because it contains all of the essential amino acids, which are those that your body cannot produce.” In relation to other standard chicken cuts such as drumsticks which contain calories but with a smaller percentage coming from protein. This shows that despite coming in smaller quantities offals have a higher protein concentration than some more common poultry cuts. It should be mentioned that chicken breasts have a good nutritional facts (protein content at 43.1 g per serving being higher than all offals and other cuts but they are the most expensive higher than all other poultry cuts.

## Conclusion

Different edible beef and chicken offal products are available and, on sale in main retail chain stores around Gaborone currently. These products are relatively cheaper compared to standard cheaper beef and chicken cuts such as chuck/stewing beef and chicken breasts. In this study, the most expensive beef offals were the tongue and liver, with the ox heel and intestines (ox casing) and omasum (small tripe) being the cheapest. Chicken gizzards were the most expensive, with the necks being the cheapest. Proper and improved packaging and processing can be instituted to aid marketing and consumption of offal products in Botswana. The local meat industry should employ better processing, handling, packaging and presentation techniques to improve product quality, and make the products more appealing to consumers. Wide availability of the products will assist in improved food security and human nutrition in the country. Enhanced utilization of edible offals will further increase profitability of the livestock industry, mainly for the rural and communal

livestock keepers. Further, it will be critical to properly characterize local offal products; their sources, preparation and handling methods, their nutritional parameters and their utilization for human and pet food, medicinal and cosmetic uses.

## CONFLICT OF INTERESTS

The authors declare no conflict of interest in this study.

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