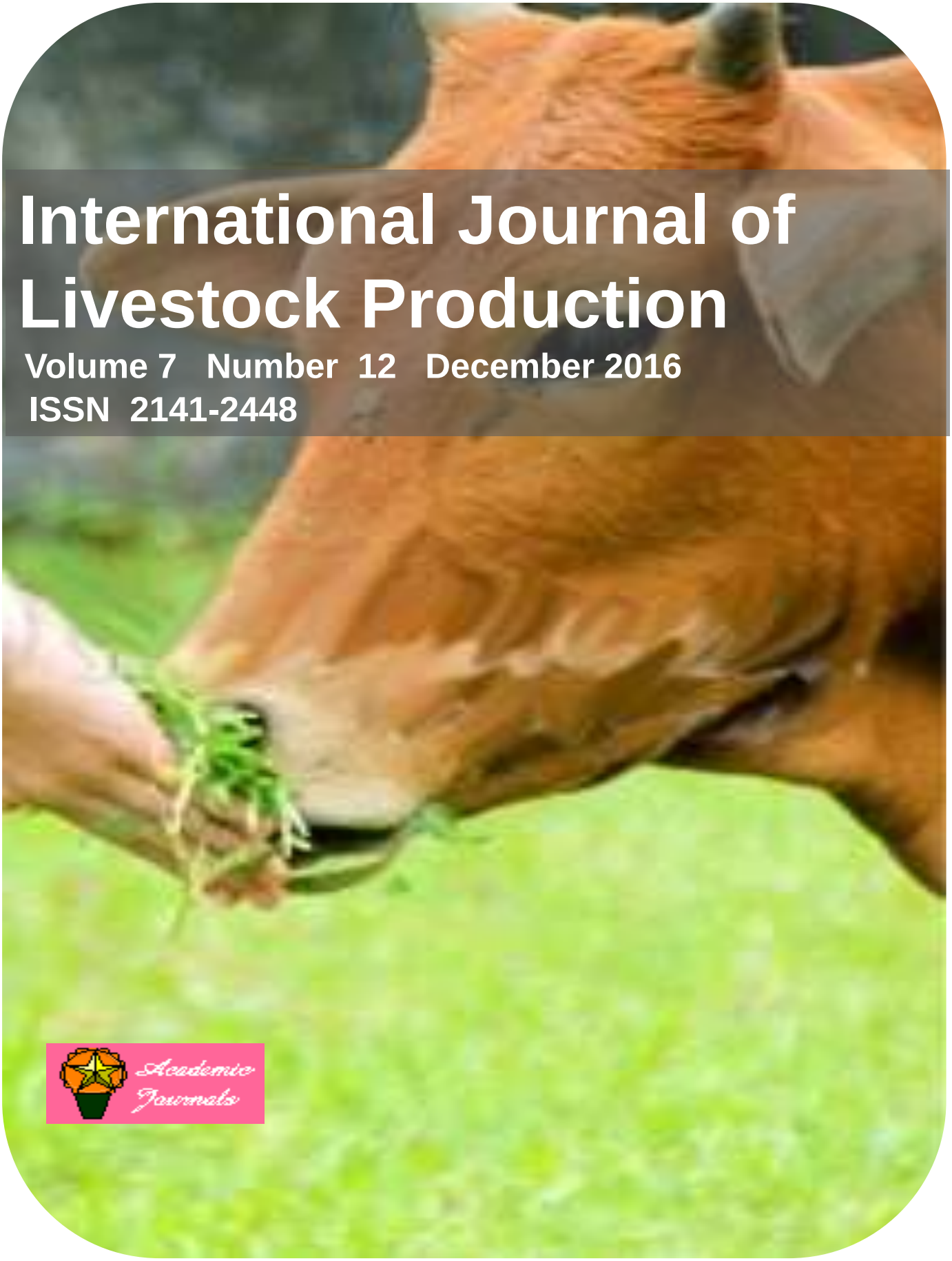

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Full Length Research Paper

Effects of tanniferous browse plant supplementation on the nutrient digestibility and growth of Djallonké rams

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Two separate experiments were conducted to investigate the effect of tanniferous (CT) browse plant supplementation on the growth, nutrient digestibility and blood biochemical properties of Djallonké sheep. The browse plants were *Albizia lebbeck*, *Gmelina arborea*, *Senna siamea* and *Ceiba pentandra* and were harvested from natural grazing fields within the vicinity of Nyankpala in Ghana. In experiment I, 20 semi-intensively kept Djallonké rams with average initial weight of 12.8±1.7 kg were randomly assigned four browse plants to evaluate their performance in terms of growth and blood biochemical properties. In experiment II, eight intensively managed Djallonké rams with an average initial weight of 13.8±1.56 kg were randomly assigned to a total mixed ration (TMR) made of browse plants, rice straw, minerals and vitamins to determine the nutrient digestibility. In experiment I, whereas lambs supplemented with the highest condensed tannin (CT) browse plant (*C. Pentandra*) had improved (P<0.05) ADWG compared to the control, it did not differ from the ADWG reported in lambs that were supplemented with A. *lebbeck* even though it did not contain measurable levels of CT. The blood metabolites did not differ among treatments. In experiment II, lambs fed with *S. siamea* ration had the lowest DMI with the highest reported in *G. arborea*. Lambs fed with *A. lebbeck* TMR had the highest (P<0.05) CP digestibility and nitrogen balance. The lowest NDF and ADF digestibility were obtained in animals fed the *G. arborea* diet. The tanniferous browse plants used in this experiment were high in nutritive value and resulted in improved live weight of lambs. They could be fed as supplement to lambs grazing natural pasture during periods of feeds scarcity.

Key words: Browse plants, blood metabolite, condensed tannin, Djallonké sheep, digestibility.

INTRODUCTION

The low nitrogen content and high levels of recalcitrant cell wall content of forages and non-leguminous based crop residues like rice straw and maize stover especially in the dry season account for the low intake, digestibility and growth of Djallonké rams in the tropics (Yisehak et al., 2014a). Leaves of trees, serve as important sources of nutrients for ruminants in most tropical countries due to their abundance and accessibility. A number of trees and

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shrubs have been identified as being suitable for feeding livestock (Le Houerou, 1980; Yisehak et al., 2014b). Evaluation of these trees to ascertain their true feeding value has been on-going for some time (Larbi et al., 2008). The leaves of trees (browse) have been shown to contain high amounts of N and low fibre particularly in the dry season when the quality of most forages have dwindled (Seresinhe et al., 2012).

Tropical browse plants have also been found to contain varying levels of condensed tannins (CT) which could have an impact on voluntary feed intake, rumen N and carbohydrate degradation (Getachew et al., 2000; Hariadi and Santoso, 2010). The negative effects of tannins (low feed intake, low digestibility, toxicity) have been reported to occur when ruminants consume forage with CT levels above 50 to 55 g/kg DM (Min et al., 2003). The effect of CT on animal performance is influenced by the source, concentration and molecular weight of CT (Butler and Rogler, 1992; Waghorn, 2008; Nauman et al., 2014).

The use of CT browse plants could play an important role in reducing the amount of ammonia excreted via urine into the environment through the reduction of rumen protein degradation (Hariadi and Santoso, 2010).

This study was undertaken with the aim of evaluating the performance of Djallonké sheep receiving different tanniferous browse plants as supplements on feed intake, weight gain, dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) digestibility and blood metabolites in the Savannah Zone of Ghana.

MATERIALS AND METHODS

Study area for experiment

The study was carried out at the Nyankpala Campus of the University for Development Studies, Tamale, Ghana. Nyankpala is about 18 km west of Tamale in the Tolon District. It is located on latitude 9° 25′ 41″ N and longitude 0° 58′ 42″ W at an altitude of 183 m above sea level. The area is in the Guinea Savannah Zone characterized by a unimodal rainfall pattern. Rains begin in April, rising to a peak in August toSeptember and ending in October or November. Rainfall averages 1060 mm per annum. Temperatures range from as low as 15°C in January when the weather is under the influence of the North Easterly (Harmattan) winds and as high as 42°C around the end of the dry season in March.

Experiment I

A total of 20 one year old male intact Djallonké lambs were purchased from the livestock market at Katingdaa in the Tolon District. The animals were quarantined for 2 weeks. The animals had an initial average weight of 12.8±1.7 kg and were assigned to 4 treatments with 4 replicates each in a completely randomised design. The treatments were shade dried *Albizia lebbeck*, *Gmelina arborea*, *Senna siamea* and *Ceiba pentandra.* In addition, 4 animals were used as controls and so did not receive any browse plant supplement. The animals were housed individually in wooden cages with concrete floors fitted with wooden feed troughs and plastic watering bowls. The animals were fed the supplement *ad libitum* at 07:00 h and were released for grazing on natural pastures at 10:00 h. The animals were led back to the pen at about 17:00 h. Water was served *ad libitum* and was replaced at the same time of feeding. The experiment lasted for 8 weeks with 2 weeks' adaptation period.

Dry matter intake of the supplementary diet (browse plant) was calculated by subtracting the left over feed from the feed offered after correcting for dry matter. The DMI for control animals was not measured because the animals were grazing on natural pasture.

The weekly weight of the animals was taken using a hanging scale (Camry hanging scale, ISO9001:2008, China). From the weekly live weight, the daily live weight gain was calculated by subtracting the initial weight from the final weight for each animal and dividing by the total number of days (56 days).

At the end of the 56 days, blood samples were taken from the jugular vein into clean test tubes. The blood was centrifuged to separate the serum. The serum was then transferred into another set of clean test tube and stored at 4°C until analysis was conducted.

Experiment II

Eight rams of about one year old with an average initial weight of 13.88 ±1.56 kg were randomly assigned to four separate total mixed ration (TMR) prepared from a mixture of browse plants and rice straw. The browse plants used were same as those in experiment 1. The treatment diets comprised of 58% rice straw, 40% browse and 2% minerals and vitamins. The feed was prepared by chopping the rice straw into pieces (Approximately 8 to 10 cm long). The dried leaves of each browse plant was weighed and mixed with the rice straw.

The animals were intensively housed for the entire experiment in metabolism cages made of metal and measuring 91 cm × 40 cm × 76 cm.

The 8 animals were randomly assigned to 4 treatments with two (2) animals per treatment. The cross over design was used in two different periods giving 4 replicates per treatment. The animals were allowed 10 days' adaptation to the feed and 3 days' adaptation to the cage and faecal collection bags. The data collection lasted 5 days in each period.

A sample of the feed was collected each day into plastic bags and stored at 4°C for chemical analysis. Water was served twice daily in a plastic container.

The animals were fitted with faecal collection bags to collect the total faeces voided. The bags were removed at 07:00 daily and the faecal matter weighed. After weighing, 10% subsample of the fresh faecal matter was frozen for chemical analysis.

Total urine was collected daily at 07:00 into plastic containers containing approximately 30 ml of 6 N HCl to prevent ammonia volatization (Dabiri and Thonney 2004). About 10% sub-sample was collected and stored at 4°C for N analysis.

The nutrient digestibility coefficient was calculated by difference between nutrient ingested and nutrient in faeces and was expressed on dry matter basis.

The experiments were conducted following the ethical guidelines of animal research in the University for Development Studies, Ghana.

Chemical analysis

About 50 g of the supplementary feed in Experiment I and TMR in Experiment II was collected into plastic bags and stored at 4°C. The stored feed was each bulked together at the end of the experiment and sub-sample taken for drying in a forced air oven at 105°C for 4 h.

The Nitrogen concentration of the sampled feed was determined according to AOAC (2000) using the Leco (Leco FP-528-UK) after

Table 1. Chemical composition of sole browse plants and total mixed ration (g/kg DM).

Nutrient	*G. arborea*	*C. pentandra*	*S. siamea*	*A. lebbeck*
Chemical composition of sole browse plants (g/kg DM)				
DM	374.25±0.60	365.31±1.29	448.31±0.30	394.63±0.68
CP	151.2±0.5	126.2±2.7	175.8±2.2	229.2±3.6
NDF	248.5±1.0	271.3±1.2	262.7±2.2	296.1±2.2
ADF	163.4±3.9	291.7±0.4	256.9±0.6	193.7±4.5
CT	3.7±0.2	102.8±1.7	1.8±0.2	0.00
Chemical composition of total mixed ration (g/kg DM)				
DM (g/kg)	914.4±31	953.0±0.1	934.2±0.3	914.2±2.4
CP	80.5±0.8	70.3±0.3	90.1±1.2	111.4±1.3
NDF	536.1±5.8	610.3±14.6	538.6±16.9	575.7±1.2
ADF	402.1±2.1	473.2±16.6	370.2±4.8	393.6±2.3

CP, Crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; CT, condensed tannin

which the crude protein was calculated by multiplying the nitrogen content by 6.25. The NDF and ADF were analysed using the Ankom^{200} fiber analyser (Ankom Technology, Macedon, NewYork) following the method of Goering and Van Soest (1970). Condensed tannin (CT) was estimated according to the method of Porter et al. (1986).

Pooled urine and faecal samples from each sheep were analysed for N using the micro Kjeldahl. Nitrogen balance was calculated as the difference between N consumed and the sum of faecal N plus urinary N.

The pooled faecal samples were also analysed for DM, NDF and ADF. The serum was analysed for total protein, albumin, glucose, urea, cholesterol and triglycerides using the Random Access, Fully-Automated, "Walk Away" Clinical Chemistry Analyzer (Flexor XL, Vital Scientific, Netherlands). Globulin was a calculated parameter (total protein-albumin).

Statistical analysis

Data from Experiment I was analysed using one-way analysis of variance from Genstat 12.1 (Payne et al., 2008) with the initial weight as a covariate for the live weight. Data from experiment II was analysed using the analysis of variance with the effect of period used as a block from Genstat 12.1 (Payne et al., 2008). Significant differences of mean were declared at 5%. The means were separated using Fisher's least significant difference test.

RESULTS

The analysed chemical composition of the sole browse plants and the TMR are shown in Table 1. The CP for the sole browse plants ranged from 126.2 to 229.2 g/kg DM for *G. arborea* and *A. lebbeck* respectively whilst that of the TMR ranged from 70.3 to 111.4 g/kg DM for *C. pentandra* diet and *A. lebbeck* diet respectively. The NDF was in the range of 248.5 - 296.1 g/kg DM for the sole *G. arborea* and *A. lebbeck* respectively. The highest ADF and CT were obtained in *C*. *pentandra*. In the TMR, the NDF ranged from 536 to 610 g/kg DM for *G. arborea* and *C. pentandra* respectively. The ADF was however lower (370 g/kg DM) in *S. siamea* and highest (473 g/kg DM) in *C. pentandra*.

The results of the effects of browse plants on the DMI, growth and serum metabolites are shown in Table 2. Relative to the other treatments, feed intake per animal per day was highest (87.70 g/h/day) in animals on the *G. arborea* supplement. Average daily weight gain (ADWG) was lower (P<0.05) in animals that were fed G. *arborea* and *S. siamea* supplement than the *A. lebbeck* which had no CT. However, there was no difference between *C. pentandra* and *A. lebbeck* in relation to ADWG. Animals on supplement, regardless of the CT concentration had higher (P<0.05) daily live weight gain in relation to the control. There was no significant effect of treatment on all the serum parameters.

The results on the effect of TMR in experiment II on intake and nutrient digestibility are shown in Table 3. Dry matter intake (DMI) differed significantly among the experimental diets with the least intake recorded in animals fed with *S. siamea* based diet (255.1 g/h/day).

The DMI in Experiment II, did not differ between the *C. pentandra* TMR and the *A. lebbeck* even though the *C. pentandra* had a numerically higher CT. The trend was similar for crude protein intake (CPI). The DM digestibility coefficient did not differ (P>0.05) between the *A. lebbeck* which had no CT and the other treatments. The intake of CT differed (P<0.01) among the browse plants with the highest (47.04 g/h/day) reported in *C. pentandra.* Relative to the other diets, animals fed with *S*. *siamea* based diet had the least (P<0.05) CP digestibility. The NDF digestibility and ADF digestibility differed (P<0.05) among the treatments with the lowest digestibility reported in *G. arborea*. There was no difference between the *A. lebbeck* and the high CT containing supplement (*C*. *pentandra*) for both NDF and ADF digestibility. The faecal nitrogen (Faecal N g/h/d) differed (P=0.041) among the treatments with the least recorded in *S*. *siamea*. Faecal N was higher in *C. pentandra* and *G*. *arborea* however; the values did not differ statistically from that of *A. lebbeck*. The lambs on *A. lebbeck* were superior (P<0.05) to the other

Table 2. Effects of browse plant on DM intake, growth and serum profile in experiment I.

DM intake and weight	Control	G. *arborea*	C. *pentandra*	S. *siamea*	A. *lebbeck*	SEM	p-Value
DM intake (g/h/d)	-	87.70	35.28	4.15	48.71	-	-
Initial weight (kg)	12.00	12.75	13.63	12.62	13.12	1.35	0.807
Final weight (kg)	14.07^{a}	15.34^{ab}	15.04^{ab}	15.24^{ab}	16.14^{b}	0.568	0.048
ADWG (g)	12.71^{a}	33.11^{b}	41.95^{bc}	34.98^{b}	55.59^{c}	6.47	<.001
Blood metabolites							
Alb (g/l)	20.40	20.13	21.83	22.02	21.39	1.455	0.573
TP (g/l)	63.38	64.39	64.25	65.96	65.98	4.200	0.956
Glb (g/l)	42.98	44.26	42.42	43.94	44.59	4.100	0.976
Glucose (mmol/l)	0.22	0.34	0.37	0.38	0.36	0.124	0.734
BUN (mmol/l)	8.48	8.39	7.13	6.75	7.55	1.466	0.674
Cholesterol (mmol/l)	1.18	1.18	1.08	1.28	1.14	0.145	0.684
Triglycerides (mmol/l)	0.54	0.63	0.49	0.64	0.51	0.243	0.944

Alb, Albumin; TP, total protein; Glb, globulin; BUN, blood urea nitrogen; ADWG, average daily weight gain; SE, standard error of means; same row with different letters point to differences in means at $P<0.005$.

Table 3. Effect of total mixed ration on intake and nutrient digestibility in experiment I.

Parameter	Treatment means					
	A. lebbeck	*C. pentandra*	*G. arborea*	*S. siamea*	SEM	p-Value
DMI (g/h/d)	468.3^{b}	456.1^{b}	509.1^{b}	255.1^{a}	24.91	0.001
CPI (g/h/d)	52.39^{d}	32.17^{b}	40.99^{c}	23.12^{a}	3.35	<0.001
N intake (g/h/d)	8.38^{d}	5.15^{b}	6.56^{c}	3.70^{a}	0.537	<0.001
CT intake (g/h/d)	0.00	47.04^{c}	1.88^{b}	0.46^{a}	0.285	<.001
Faecal N (g/h/d)	0.25^{ab}	0.30^{b}	0.37^{b}	0.17^{a}	0.06	0.041
Urine N (g/h/d)	0.29	0.15	0.22	0.36	0.08	0.099
DM (Coefficient of digestibility)	0.69	0.64	0.59	0.57	0.06	0.141
CP (Coefficient of digestibility)	0.94^{c}	0.91^{b}	0.91^{b}	0.84^{a}	0.01	<0.001
NDF (Coefficient of digestibility)	0.68^{b}	0.65^{ab}	0.55^{a}	0.73^{b}	0.05	0.020
ADF (Coefficient of digestibility)	0.62^{b}	0.56^{ab}	0.46^{a}	0.67^{b}	0.06	0.030
N balance	7.84^{d}	4.69^{b}	5.97^{c}	3.16^{a}	0.53	<0.001

DMI, Dry matter intake; CPI, crude protein intake; N, nitrogen; SE, standard error of means; same row with different letters point to differences in means at $P<0.005$.

treatments in terms of the nitrogen balance (N balance) with the least reported in lambs that fed on *S. siamea*.

DISCUSSION

The four browse plants in Experiment I and total mixed ration in Experiment II had a CP level above the minimum 60 to 80 g/kg DM required to depress appetite, voluntary feed intake and sustain microbial growth (Van Soest, 1982; Belachew et al., 2013). The CP content of the browse plants was in the range of what has been generally reported for browse plants (Ouédraogo-Koné et al., 2008). The high ADF compared to NDF in the sole *C. pentandra* agrees with the findings of Getachew et al. (2000) for some tanniferous plant species and is attributed it to the insoluble complex formed between CT and CP in the NDF solution which became soluble in ADF solution. The relatively lower NDF reported in the sole browse plants compared to the TMR could results in poor animal performance when they are fed as sole diet under intensive system since lower amounts of fermentable carbohydrate will be available. In addition to this, the cumulative effect of the CT could depress feed intake and digestibility.

The lowest feed intake reported in *S. siamea* in both experiments despite the appreciable level of CP (175.87 g/kg) calls for further investigation. The findings in this present study do not agree with earlier reports that attributed the high DM intake in Djallonké sheep to the high CP content of the test diet (Konlan et al., 2012). The condensed tannin (CT) in *S. siamea* was lower than what

was reported in *C. pentandra* but the DM intake did not reflect this. It has been reported elsewhere that high tannin levels have a negative effect on feed intake by causing astringency (Al-Mamary et al., 2001).

In Experiment 1 all the animals gained weight during the period of the study. However, the non-supplemented animals had the lowest ADWG, indicating that browse plants supplementation can enhance the growth of animals grazing natural pasture. The ADWG was not different between C. *pentandra* which had the highest CT and A. *lebbeck* which had no CT. This could be attributed to efficient protein degradation in the rumen of animals that were supplemented with C. *pentandra* (Getachew et al., 2000; Hariadi and Santoso, 2010). It is interesting to note that lambs that fed on *G. arborea* though had the highest DM intake did not correspond to a higher ADWG in experiment I. This might be due to a relatively poor nutrient absorption and utilization in the animals fed the *G. arborea* supplement. The relatively low DMI reported in animals supplemented with S. *siamea* was expected to lead to a lower weight gain similar to the control. That did not happen in this present study suggesting that S. *siamea* may possess certain growth enhancing properties which needs to be investigated.

The total protein (TP), globulin, albumin, blood urea nitrogen and cholesterol compared favourably with the findings of Olafadehan (2011) who fed tannin rich browse plants to West African Dwarf goats. The lack of significant difference in blood metabolites among the lambs that fed the tanniferous browse plants and the *A. lebbeck* suggests that the level of tannin intake did not negatively affect proteolysis in the rumen. This could also mean that tropical animals are able to tolerate high CT diets as is the case in the C. *pentandra*.

The high BUN level reported in the control despite the low weight gain could suggest that there was some level of body protein catabolism in the control group (Leibholz, 1970).

When the browse plants especially *C. pentandra* were fed with rice straw in a TMR to lambs, the DM digestibility did not differ indicating that rumen environment and function were not affected negatively by the presence of CT. This might be due to the inclusion levels, CT concentration and type of browse used. Hervas et al. (2003) did not find significant difference in DM digestibility when CT containing browse plants were fed to ruminants. Even though the CP digestibility of *A. lebbeck* based TMR relative to the other treatment was higher ($P<0.05$), they were all above 80%. This could indicate that the CT did not negatively affect protein degradation in the rumen.

The lack of difference in NDF and ADF digestibility between the *A. lebbeck* based TMR and *C*. *pentandra* suggests that there was no negative effect of the CT on the cellulolytic microbes. It has been suggested that the CT: Protein complex interferes with the ability of cellulolytic bacteria especially *Fibrobacter sucinogenes* to form an attachment with plant cell wall thereby reducing digestion rate since the presence of plant protein in the rumen for microbial breakdown aids in microbial attachment to plant cell wall (Mitsumori and Minato, 1993). The NDF and ADF fractions are part of the structural carbohydrates that supply substrate for cellulolytic microbes to provide acetic and butyric acids for lipogenic nutrient to be made available to the host animal (Smith and Crouse, 1984).

Conclusion

The nutrient composition of the browse plants studied especially CP was within the levels required to enhance feed intake and digestibility. When the browse plants were used in a mixed ration with rice straw, the nutrient composition and digestibility were not negatively affected. Feeding Djallonké sheep that are grazing on native pasture with browse plants as supplement enhanced ADWG with no negative effects on blood metabolites. A further study is recommended to investigate different feed processing methods of S. *siamea* on DMI and growth of Djallonké sheep.

Conflict of interests

The authors have not declared any conflict of interests.

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Performance and Haematological Parameters of Rabbits fed graded levels of Bitter kola (*Garcinia kola*)

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The need to reduce cost of production of meat animal has necessitated the use of plant materials with medicinal properties as feed additives capable of minimizing the influence of pathogenic microbes and improving performance of the animal. This study investigated the effect of such medicinal plant materials *Garcinia kola* on the growth performance and the haematological parameters of 20 weeks old rabbits. Thirty six rabbits of mixed breed and mixed sexed were used for the experiment, which lasted for eight weeks (56 days). The rabbits were randomly assigned to four dietary treatments: T_1 with no (0%), T_2 (2.5%), T_3(5%) and T_4(7.5%) of *G. kola* inclusion. The rabbits were housed in 2m × 1m × 1m cages per three rabbits in a 4 × 3 CRD experimental design whereby each treatment had three replicates, with each replicate having 4 rabbits and each treatment comprised 12 rabbits. During the eight week period of the experiment, feed and water were given ad libtum and while similar managerial and sanitary measures were applied for all the animals. Daily feed intake and growth performance of animals in each unit were monitored. At the beginning and the end of the experiment, blood samples were collected from the ear and analyzed for haematological parameters Hb, PCV, RBC, WBC and Plasma proteins). The result showed that *G. kola* has significant effect on the feed intake, growth rate, haemoglobin, PCV, RBC, WBC and Plasma protein. The feed intake decreased in all rabbits on *G. kola* treated feeds; numerical values obtained were 332 ± 0.32, 285 ± 0.52, 288 ± 0.12 and 262 ± 0.33 g/week for treatment 1, 2, 3, 4 respectively. Weight depression was also observed similarly in all the rabbits on Garcinia treated feeds with T2 having weight loss of 0.36 ± 0.11, T30.35 ± 0.12 and T4 0.64 ± 0.10kg.
Rabbits on Garcinia treated feeds also have lower Hb, PCV, Plasma proteins and higher WBC and RBC compared to the initial values showing *G. kola*. *G. kola* appear to contain substances which depress feed intake and growth performance and the effect seem to increase with higher concentration. However, the RBC and WBC increased, it is therefore recommended that the use of *G. kola* should be at low levels of inclusion or intermittently not continuous.

Key words: *Garcinia kola,* growth performance, rabbits.

INTRODUCTION

Traditional animal healthcare practices involving use of some materials and herbal preparations called ethno-veterinary medicine is fast gaining grounds in the livestock industry especially in African and Asian countries (Ebenebe et al., 2010; Ojelade, 2015) as they provide readily available and low cost alternative to orthodox medicine. Of the herbal drug, the use of garlic (*Allium sativum*), ginger (*Zingiber officinale*), neem tree leaves

(*Azadiractha indica*) and most recently bitter kola (*Garcinia kola)* have been reported in livestock health care management (Ebenebe et al., 2010; Esonu 2006, Owen and Amakiri 2013 and Obun et al., 2013). *Garcinia kola* is a dicotyledonous belonging to the family Guttiferae or Clusiaceae and is widely cultivated throughout West Africa (Adedeji et al., 2006). In Nigeria, Otor et al. (2004) reported that *G. kola* is common in the South western states and Edo State. According to Chilaka (2009), *G. kola* is used for social, therapeutic and nutritional purposes. The pharmacological use of *G. kola* which is of utmost importance in many regions of Africa has been documented by many authors (Iwu et al*.,* 1993; Ofor et al., 2010; Okunji et al., 2007). Farombi et al. (2002) and Okunji et al. (2007) identified certain substances with antibacterial, anti-oxidative, anti-hepatoxic and hypoglycemic properties. Iwu et al. (1993) identified purgative, anti-parasitic and anti- microbial properties of *G. kola*.

The usefulness of *G. kola* in counteracting clinical and subclinical diseases that could hamper the performance of animals can only be ascertained by assessing its effect on growth performance of the animal and other haematological parameters. Owen and Amakiri (2015) noted that haematological parameters are indicators of the health status of animals and so constitute an indispensable tool in the diagnosis, treatment and prognosis of many diseases. Barnajee (2008) showed that haematological constituents of blood are valuable in monitoring feed toxicity especially feed constituents that affect the formation of blood. Ewuola and Egbunike (2008) also posited that haematological parameters appraise the health status of animals as they are indices of the effect of dietary treatments on the physiology of the animal. The most commonly used haematological parameters include Packed Cell Volume (PCV), White Blood Cell count (WBC), Red Blood Cell count (RBC), Haemoglobbin (Hb) and Plasma proteins (Dada and Ikeuerowo, 2009; Ahumibe and Braide, 2009). Mitruka and Rawnsby (1997) outlined normal ranges of haematological parameters for most animals. Esomonu et al. (2005) reported significant reduction in PCV, RBC and Hb in rats treated with 2 g/kg of *G. kola* in the 1st week of the trial but non-significant in the 2nd to 5th week while Dada and Ikeuerowo (2009) on the other hand reported non - significant change in the erythrocyte values of fish fed various concentrations of *G. Kola*. The result of aqueous, methanolic and ethanolic extract of *G. kola* in the haematological parameters of rabbits and rats has been fraught with inconsistencies. Osifo et al. (2013) investigated the effect of methanolic extract of *G. kola* on the haematological parameters of adult male rabbit and obtained significant reduction in the PCV, Hb, Neutrophil and eosinophil counts and significant increase in the WBC, Lymphocytes and Monocytes counts. Apart from haematological parameters, *G. kola* has been reported to depress feed intake and weight of rabbits (Uko et al., 2001; Notridge et al., 2008). However, the exact concentration that is detrimental to the performance and health of rabbits at the various stages of life is yet to be conventionally established. This study therefore investigates the effect of various concentrations of *G. kola* on growth performance and haematological parameters of 20 weeks old rabbits of mixed breed and mixed sexes fed diets containing graded levels of *G. kola.*

MATERIALS AND METHODS

Thirty six and twenty weeks old rabbits of mixed breeds and mixed sexes purchased from teaching and research farm of University of Nigeria, Nsukka (UNN) was transfered to the Rabbitry unit of the Department of Animal Science, Nnamdi Azikiwe University, Awka were used for the study. The rabbits were left in the cages to acclimatize for one week before being assigned to their respective dietary treatments. Before the on-set of the experiment, the rabbits were weighed individually and randomly assigned to labeled cages of 2 m × 1 m × 1 m in such a way that each cage housed male and female from each of the two breeds to counter the sex and age effect.

At the on-set of the experiment, blood was collected from the marginal vein of the ear in each of the rabbits, the blood was drained into blood vials containing Ethylene Diamine Tetra Acetic Acid (EDTA) bottles, while the blood for PCV was drained directly into labeled haematocrit capillary tubesto two-third full with one end of the capillary tube sealed with plasticine. The tubes were placed in microhaematocrit centrifuge and spun at 10,000 rpm for 5 min. Thereafter, the PCV was read with microhaematocrit reader and the readings were expressed in perecentage. For the WBC, the blood in the vial with EDTA was carefully drawn to 0.5 mark on white cell pipette and mixed thoroughly after the vial has been covered with finger tips. At an angle of 45°, the blood in the vial introduced into the improved Neubauer counting chamber (Haemocytometer) without allowing the fluid to overflow. The chamber was then placed on the microscope stage and allowed to settle for 10 min, so that using the 4mm objective and ×10 eye piece, all the cells were counted including cells touching the borderlines on the top and right hand side. For the RBC, the blood was also drawn to 5 mm mark on the pipette and made up to 101 mark (that is, to the point immediately above the bulb) with diluting fluid (3.0 g sodium citrate, 1.0 cm^3 formaldehyde and 100 cm^3 distilled water). Introduction of the blood into the counting chamber followed similar procedure as the case of WBC but counting was in five groups of 16 small sqaures in the centre millimeter square area that is 80 out of the 400 small sqaures. The haematological analysis was carried out at the Laboratory of the Zoology Department, Nnamdi Azikiwe University, Awka by Ufele A.N an animal physiologist in the research team. The rabbits were then subjected to dietary treatments containing 0% (T1), 2.5% (T2), 5% (T3) and 7.5% (T4) of *G. kola*, respectively.

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Table 1. Gross composition of the experimental diets.

Ingredients	Percent composition			
	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Maize	40.0	39.00	38.0	38.0
Soybean Cake	7.00	6.00	5.00	4.00
Fish meal	1.00	1.00	1.00	1.00
Bitter Kola*	0.00	2.50	5.00	7.5
Wheat Offal	47.0	46.50	46.0	44.5
Blood Meal	1.00	1.00	1.00	1.00
Bone Meal	3.00	3.00	3.00	3.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
TM/Vit Premix	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**

Table 2. Proximate Composition of the Experimental Diet.

Parameter	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Crude Protein (CP)%	16.38	16.06	15.73	15.34
Crude Fibre (CF) %	5.27	5.24	5.21	5.12
Ether Extracts (EE)	3.55	3.48	3.42	3.36
Ca %	1.25	1.29	1.33	1.37
P %	0.62	0.62	0.62	0.62
Lysine %	1.05	1.02	0.99	0.96
Methionine%	0.51	0.50	0.49	0.48
Energy (ME Kcal/Kg)	2486.50	2481.96	2477.42	2488.18

Other ingredients in the diet are shown in Table 1. The experiment was based on 4 × 3 CRD whereby each treatment had 12 rabbits, 4 rabbits per replicate and three replicates per treatment. The experiment lasted for 8 weeks (56 days) during which time the rabbits were given feed and water ad libtum and were subjected to similar sanitary and husbandry conditions. The daily feed intake was recorded while the weight records were taken on weekly basis using precision weighing balance for the eight weeks period of the experiment. At the end of the experiment, similar procedure described above was followed to collect blood samples for analysis of Hb, WBC, RBC and plasma proteins, as well as that for PCV analysis. Data generated from the experiment were analyzed statistically using ANOVA for CRD test while differences in means were assessed for significant differences using Duncan Multiple Range Test.

RESULTS

Proximate compositions of dietary treatment

The gross composition of the experimental diets is presented in Table 1 while the proximate composition is presented in Table 2. Table 2 presented percentage nutrient content of each of the dietary treatments. The dietary treatments are of similar protein and energy content such that the major source of variation is the inclusion level of *G. kola.* The crude protein content ranged from 15.34% in Treatment 4 with 7.5% level of *G. kola* inclusion to 16.38% in Treatment 1 with no *G. kola* inclusion. The energy content ranged from 24877.42 kcal/kg in Treatment 3 to 2488.18 kcal/kg in T3. However, there was no significant difference in the crude protein and energy content of the dietary treatments.

Proximate composition of *G. kola*

The result of the proximate composition of *G. kola* on Dry matter basis showed CP 2.64%, CF 20.51%, EE 9.47%, Ashes 1.07% and NFE 57.54%. The result showed that *G. kola* has very little protein, high fibre, ash and NFE.

Effect of dietary treatment on the performance of rabbits

The effect of the dietary treatment on the performance of the rabbits is presented in Table 3. The result showed

Table 3. Effect of the Dietary Treatment on the Performance of the Rabbits.

Parameter	T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Initial weight (kg)	1.58 ± 0.10	1.56 ± 0.15	1.53 ± 0.13	1.55 ± 1.00
Final weight (kg)	1.97 ± 0.12[a]	1.18 ± 0.14[b]1	1.08 ± 0.18[b]	0.91 ± 0.11[c]
Weight Gain/Loss (kg)	0. 39 ± 0.11	- 0.36 ± 0.11	-0.35 ± 0.12	- 0.64 ± 0.10
Feed Intake g/week	332 ± 0.32[a]	282 ± 0.52[b]	288 ± 0.12[b]	262 ± 0.33

+ S.E.

that the feed intake and weight was depressed progressively in all the rabbits subjected to *G. kola* based diet as the inclusion level increased from 2.5 to 7.5%. The final weight of the rabbits follows the opposite trend with the rabbits on control diet without *G. kola* treatment having highest final mean weight of 1.97 ± 0.12 kg and the least final mean weight of 0.91±0.11 kg in T4 with 7.5% thus, indicating weight loss on rabbits on *G. kola* treatment. Frutos (2004) reported that consumption of plant species such as *Garcinia kola* containing tannin (generally > 50g/kg^{-1} of DM) significantly reduced voluntary food intake in ruminants while medium or low consumption (> 50g/kg) seem not to affect it. Glick and Joslyn (1970) had earlier reported the food intake depression and subsequent decrease in weight of rats fed tannic acid. The decrease in food intake and weight loss in rabbits fed on diets with *G. kola* inclusion may therefore be associated with tannin content of *G. kola*. Although, Monago and Akhidue (2002) reported low content of tannins in *G. kola*, the percentage inclusion and period of feeding may be responsible for the result obtained in this study. *G. kola* also contain oxalate which is known to form a strong chelate with dietary calcium and other divalent metals and makes them unavailable for consumption (Abara et al., 2000). This coupled with inhibition of protein metabolism by tannins in *G. kola* may be responsible for weight depression in rabbits fed on *G. kola* in this study.

Haematological parameters of rabbits fed on *G. kola* based diet

The effect of dietary treatments on the haematological parameters of the rabbits fed on various levels of *G. kola* is presented in Table 4.

Effect of *G. kola* treatment on the haematological parameters

The result showed that the Hb values and plasma proteins of rabbits that received *G. kola* treatment were significantly ($P < 0.05$) lower than the values for the control. The Hb level for all treatments however was within the standard range 10.4 to 17.4 g/dl recommended for healthy rabbits (Mitruka and Rawnsley, 1977). Numerically, the Hb value for rabbits in the control was 11.50 ± 0.98 while that of treatment 2 to 4 were 10.02 ± 0.42, 9.50 ± 0.07 and 9.31 ± 1.06 g/dl constituting loss of 0.43, 1.15 and 1.00 g/dl in the respective *G. kola* treated feeds.

The result of plasma protein followed the same trend with loss of 0.15, 0.50 and 0.20 respectively. The PCV values obtained in the study were also within the normal range of 30 to 50% for healthy rabbits. There was significant difference ($P < 0.05$) in the PCV values obtained in all the treatments between the rabbits in the control and that of those in *Garcinia* treated feeds l with the highest loss in PCV value occurring in rabbits fed 7.5% *G. kola*. Esomonu et al. (2005) reported significant reduction in PCV, RBC and Hb in rats treated with 2 g/kg of *G. kola* in the first week of their trial but non- significant in the 2nd to 5th week of the trial. Osifo et al. (2013) also showed significant reduction ($P < 0.05$) in the PCV, Hb, neutrophil and eosinophil counts of rabbits fed with methanolic extract of *G. kola* and significant increase ($P < 0.05$) in the WBC and lymphocyte counts and an unchanged monocyte and basophil counts. The result therefore disagrees with Ahumibe and Braide (2009) who reported significant increase in PCV, Hb, and RBC in response to treatment with *G. kola*. Saponin content of *G. kola* may be responsible for these results. Monago and Akhidue (2002) remarkable high concentration of saponins in G. kola (15.79 ± 0.28 g/100 g DM). This concentration according to them may be deleterious when high concentration is consumed. Saponins induces haemolysis of erythrocytes (Onning et al., 1996), decrease in plasma cholesterol and bile acid production (Oakenful and Sidhu 1990). There is also an irreversible reaction of saponin with membranes of animals and cells as saponins render the cells non permeable. The dosage and saponin content of *G. kola* may be responsible for the inconsistent results from various authors. Besides, Monago and Akhidue (2002) reported high content of cyanogenic glycosides (59.56 + 0.05 mg/100 g DM) in *G. kola* which upon hydrolysis yields hydrogen cyanide (HCN) and thus, toxic at certain concentrations. HCN inhibit respiratory chain, therefore inhibiting metallo-enzymes such as cytochrome oxidases (Montgomery, 1980 cited in Monago and Akhidue, 2002). The study showed significant increase in WBC count in response to

Table 4. Mean Values of the Haematological Parameters from Each Dietary Treatment.

Haematological parameter		Treatment level inclusion			
		T_1 (0%)	T_2 (2.5%)	T_3 (5%)	T_4 (7.5%)
Hb g/dl	Initial	10.25 ± 0.35	10.45 ± 0.64	10.65 ± 0.71	10.35 ± 1.20
	Final	11.50 ± 0.98	10.02 ± 0.42	9.50 ± 0.07	9.35 ±1.06
	Gain/loss	1.25*	-0.43[b]	-1.15[a]	-1.00[a]
PCV (%)	Initial	33.50 ± 0.70	34.55 ± 0.70	34.60 ± 0.70	34.00 ± 2.83
	Final	33.80 ± 1.41	32.80 ± 2.12	32.75 ± 0.71	31.40 ± 0.71
	Gain/Loss	0.30	-1.75[b]	- 1.85[b]	- 2.60 [a]
WBC ($\times 10^5/mm^3$)	Initial	5.20 ± 0.28	5.20 ± 0.11	5.20 ± 0.28	5.20 ± 0.28
	Final	5.53 ± 0.57	5.90 ± 0.42	6.45 ± 0.49	7.40 ± 0.71
	Gain	0.33*	0.70[c]	1.25 [b]	2.20 [a]
RBC ($\times 10^6/mm^3$)	Initial	5.25 ± 0.35	5.15 ± 0.07	5.40 ± 0.21	5.45 ± 0.13
	Final	5.55 ± 0.77	5.35 ± 0.28	5.55 ± 0.31	5.30 ± 0.71
	Gain	1.30[a]	0.20[b]	0. 15[b]	0.15[b]
Plasma protein	Initial	42.50 ± 4.95	39.95 ± 4.95	41.85 ±1.95	41.80 ± 1.15
	Final	43.50 ± 2.12	39.80 ± 0.07	41.35 ± 0.35	41.60 ± 2.83
	Gain/Loss	1.00*	- 0.15[c]	-0.50[a]	-0.20[b]

Mean values are used, * Refer to gains Hb= Haemoglobbin, PCV= Packed Cell Volume, WBC= White Blood Cell, RBC= Red Blood Cell. The result showed decrease in the blood haemoglobin content and plasma protein of rabbits fed *G. kola*. The least record was in T3 with 5% level of inclusion, however, the WBC content increased progressively as the *G. kola* inclusion level in the diet increased.

G. kola treatment with the highest value recorded in Treatment 4 and the least in the control. The order of increase is T4>T3>T2>T1. The higher WBC recorded for the rabbit in the *G. kola* treated units could be attributed to the antimicrobial and anti-parasitic influence of *G. kola* effect of *G. kola* and the role it plays in the defense mechanism of the body of the animals. The result therefore suggests a well-adapted immune system for the treated groups. The result therefore corroborates the findings of Osifo et al. (2013) who reported significant reduction in PCV, Hb, neutrophil and eosinophil counts and significant increase in WBC and lymphocyte counts of rabbits fed on diets treated with methanolic extract of *G. kola.*

The result showed increase in RBC values for all rabbits in both the control and *Garcinia* treated rabbits but there was significant ($P < 0.05$) difference in the RBC values between the rabbits on the control diet and those on *G. kola* diets. The numerical values of the gain in RBC are 1.30, 0.20, 0.15 and $0.15 \times 10^6/mm^3$. Ahumibe and Braide (2009) reported increase in RBC for *Garcina* treated rats. Esomonu et al. (2005) who recorded increased RBC values in Wistar rats medicated with ethanol extract of *G. kola* seed. Unigwe and Nwakpu (2009) opined that the higher RBC counts for rabbits on bitter kola treatment could probably be due to compensatory action of the body whereby ageing RBCs were destroyed leading to release of some iron which in turn were salvaged and transported to the erythroid cells of the bone marrow for new haemoglobin and RBC syntheses.

Conclusion

The values of the haematological parameters obtained in this study were within the normal ranges thereafter, it appears that the effect of *G. kola* is not extremely detrimental to the life of the rabbit or the actions of any anti nutritional constituent of the seed, which does not exert long-term significant toxicological tendency to haematological parameters. However, *G. kola* use in rabbit production should be below 2.5% level of inclusion or be given intermittently to avoid its effect on feed intake and weight gain of the animals. *G. kola* effect on the body tissues especially the vital organs of the body should also be assessed in further studies. Besides, the findings of this study will also serve as a note of warning to many humans who are addicted to consumption of *G. kola* especially in this part of the world.

Conflict of interest

The authors have not declares any conflict of interest.

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Effect of three different diets on sensory attributes and meat quality of feedlot finished Tswana yearling steers

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The study was conducted to assess the effect of roughage source on meat quality and sensory attributes of yearling Tswana cattle. The sensory traits and meat quality of yearling Tswana steers fed maize stover diet (treatment A), sorghum stover diet (treatment B) or commercial beef finisher diet (treatment Control) were evaluated and allotted feeding trial by adopting Completely Randomized Design (CRD). The commercial diet had Lucerne (*Medicago sativa*) as a roughage source at inclusion level of 15% in total diet dry matter. Animals were slaughtered after 24 hour fast at Botswana Meat Commission (BMC) at Lobatse and samples were collected by cutting approximately 5 kg rump steak of the left side of halved carcasses. Trained individuals were used in sensory consumer evaluation to assess flavor, tenderness, moistness, appearance and overall impression of meat using eight point hedonic scales. No significant difference between the treatment groups for meat colour attribute was found. However, the colour values are slightly lower for the treatments indicating paler colour of the meat. There was also no significant difference among treatments in tenderness (P > 0.05) although treatments A and B almost significantly differed (P = 0.067). The proximate parameters crude protein, moisture and total fat were similar in all treatments (P > 0.05). There was statistically significant difference for muscle pH between sorghum stover diet (5.5) and commercial beef finisher diet (5.0) at P < 0.05. The pH values of meat from maize stover diet and sorghum stover diet were within the normal pH range of 5.4-5.8 which is an indication of good quality product. The sensory evaluation of rump steaks from yearling Tswana steers showed that 86% of the panelists rated meat steaks highest on overall impression from maize stover diet finished animals followed by 79% rankings from sorghum stover diet finished animals while steak cuts from commercial diet were the least ranked from like moderately to like extremely. It was concluded that meat products from cereal stover diets had good meat qualities and overall acceptability as compared to commercial beef finisher diet.

Key words: Commercial beef finisher, maize stover diet, meat quality, sensory attributes, sorghum stover diet, yearling Tswana bulls.

INTRODUCTION

Meat production is normally based on the growth and development of the animals, while site of fat and amount in the carcass determines the quality of meat (Mahgoub and Lu, 1998). The attributes of meat quality includes flavor, juiciness, tenderness, colour and muscle pH. These attributes are useful particularly on the evaluation of chemical and sensory assessment of meat (Dhanda et al., 1999). Generally meat supplies human beings with

quality proteins in the form of essential amino acids, essential vitamins and minerals (Sebibe, 2014). The overall meat consuming quality is influenced by tenderness and juiciness attributes (Chulayo and Muchenje, 2013). In most cases meat quality is influenced by muscle pH, however consumers usually evaluate meat qualities basing on the tenderness, juiciness and flavor attributes of cooked meat (Chulayo and Muchenje, 2013).

Myoglobin content and nature, the composition and physical state of muscle are the key determinants of meat colour (Renerre, 1990). Consumers use meat colour to assess meat quality and acceptability (Conforth, 1994). The freshness of meat and quality is highly influenced by desirable colour (Machete et al., 2012). There are so many other aspects during beef production such as cattle genetics, use of implants, feeding practices, quality of feedstuffs as well as meat processing procedures which influence the variation of beef quality or characteristics in various countries around the world (Killinger et al., 2004). Fresh products can be potentially affected in variable manner by these above mentioned factors. Normally the palatability of the product is influenced by aging of the fresh meat. Research has shown that meat aging is associated with development of flavors and incremental tenderness with time (Sitz et al., 2006). The current study was carried out in order to address the lack of documentation or characterization information of this indigenous Tswana breed of cattle in the aspect of meat evaluation. Therefore, the study was conducted to assess the effect of roughage source on meat quality and sensory attributes of yearling Tswana cattle.

MATERIALS AND METHODS

The study was conducted at the Department of Agricultural Research (DAR) feedlot facility at Sebele (24° 33''N, 025° 54''E,**)** 10 kilometers from Gaborone, Botswana. Twenty-seven Tswana yearling steers (227±11 kg) obtained from ranches of DAR were used in a 93-day feeding trial by adopting Completely Randomized Design (CRD). Tswana cattle are the famous indigenous cattle breed of Botswana, which are closely related to the humped Sanga cattle. The adult size is approximately 400 kg and an 18 month old weighs roughly 250 kg when raised extensively under communal natural pastures (Animal Production Research Unit Report, 1992).

Slaughtering and Sampling

Twenty-seven intact yearling Tswana steers from a feeding trial were transported to a slaughter abattoir, Botswana Meat Commission (BMC) a day before they were subjected to slaughter procedures. There were three dietary treatments of maize stover diet (30% roughage level, treatment A), sorghum stover diet (30% roughage level, treatment B) and commercial diet (15% roughage level, treatment control,C). Formula feed (ground maize, 57.8%; maize stover, 30%; molasses cane, 65%; wheatbran, 2.1%; urea, 1.5%; limestone,1.1%; vitamin premix, 0.5%; dicalcium phosphate, 0.3% and salt, 0.2%) was used for maize stover diet, formula feed (ground maize, 55.1%; molasses cane, 6.5%, wheatbran, 4.7%; urea, 1.5%; limestone, 1.2%; vitamin premix, 0.5%; dicalcium phosphate, 0.3%; salt, 0.2% and sorghum stover, 30%) was used for sorghum stover diet. The cereal-based diets were formulated to have Crude protein content of 12.5%. Ingredients composition of the commercial diet was unknown and it was formulated to have minimum crude protein content of 12%. Each dietary treatment had nine yearling steers which were individually fed. Animals were slaughtered after a 24 h fast in this commercial slaughter house BMC at Lobatse and samples were collected from the running conveyor belt automatic system by cutting approximately 5 kg rump steak of one left side of the halved carcasses. All rump steak samples were kept in cooler boxes on ice blocks and transported to Botswana College of Agriculture (BCA) Meat Science Laboratories for further analysis. One quarter of each rump steak were cut after 24 hours ageing and sent to National Food Technology Research Centre (NFTRC) laboratories at Kanye for chemical analyses. All samples at BCA Meat science laboratory were kept at -20 ^{0}C until analyses of meat pH (pH done obtained from post-thawing sample), sensory evaluation and meat firmness procedures were carried out except for small portions which were for meat colour assessment, done the following morning on fresh, non-frozen samples (Sawyer et al., 2007).

Instrumental objective colour

The meat colour of external surface of the muscles was measured using Precision Meat colorimeter, mini-scan, model NR20XE of Shenzhen 3NH Technology Co., LTD, Shenzhen, China. The device had a 2.54 cm port and was standardized using a black tile and a white tile. Readings were taken from two random locations on each muscle and the average of the readings for lightness (L*), redness (a*), and yellowness (b*) were recorded (Sawyer et al., 2007).

Measurement of pH

The 200 g post-thawing portion of rump steak samples was used for pH determination using Portable waterproof meat pH meter, model HI99163 of Hanna Instruments, USA. The pH meter was equipped with a temperature-compensating combination pH electrode and probe calibrated to both pH 4.0 and 7.0. The meter is fitted with a sharp probe which pierces through the muscles, and readings were obtained from three locations on each sample and the average of the readings was recorded (Lee et al., 2008).

Instrumental firmness measurement / Tenderness

The objective evaluation of tenderness was performed using Digital Firmness Tester model Agrosta R 15, electronic durometer designed and manufactured by AGRO-TECHNOLOGIE of APOLLINAIRE lm AEROSPACE and INSTRUMENTS, France. Meat samples were thawed at 4°C for 24 h and then meat samples from rump steak were boiled and fry-finished to an internal temperature of 72°C or well done. The cooked samples were allowed to equilibrate to room

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Table 1. Least square means and standard errors of mean of meat colour, tenderness and pH for rump steaks of yearling Tswana steers fed maize stover diet, sorghum stover diet and commercial diet finisher.

Traits	Treatments				
	Maize stover	Sorghum stover	Commercial diet	S.E.M	P-value
Lightness (L*)	35.37	34.44	35.73	1.071	NS
Redness (a*)	17.06	16.78	17.82	0.529	NS
Yellowness (b*)	5.45	5.5	5.8	0.266	NS
Tenderness (N)	21.25	16.44	16.56	1.777	NS
pH	5.29[a]	5.51[a]	5.02[b]	0.137	S

[a,b,c]Means with a different superscript across the row differ significantly (P< 0.05), Each value is an average of nine observations (n = 9), NS=Non significant (P > 0.05), S = Significant, S.E.M= standard error of mean.

temperature. Two cores of 2.0 cm diameter were removed from each cooked meat sample using a sharp knife. The coring was done parallel to the orientation of muscle fiber and each core was sheared at two locations with single bladed digital firmness tester device.

Chemical composition

The chemical analysis of rump steaks for steers finished on feedlot was done at NFTRC laboratories in which the Association of Official Analytical Chemists (AOAC) 1990.03, 1990 Dumas method was used for crude protein determination, AOAC 934.01, 1934 oven drying was used to obtain moisture content while total fat was determined by the FOSS Tecator application sub note for hydrolysis unit 1047 (ASN 3121); ISO 1443-1973, in focus vol.11No.1 (1998).

Sensory evaluation analysis

A total of thirty-eight orientated or semi-trained individuals were used in a sensory consumer evaluation exercise. The consumer panelists were of mixed sex (males and females) of unequal numbers that volunteered to participate in response to a verbal announcement sent to all employees of the Department of Agricultural Research and Botswana College of Agriculture as well as students of the College. The panelists rated each of the meat samples in duplicates using an 8-point hedonic scale; 1=dislike extremely; 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=neither like nor dislike; 6=like moderately; 7=like very much; 8=like extremely for meat quality attributes; flavor, moistness, appearance and overall impression. For tenderness, a 5-point scale was used; 1=much too tough; 2=too tough; 3=just about right; 4=too tender; 5=much too tender. Equal bite size from each treatment were coded and served in an odourless formy plates or containers. Each sample was evaluated independent of the other on a well-structured consumer ballot sheet.

Statistical analysis

The analysis of variance (ANOVA) for the objective meat colour, meat pH, instrumental firmness and chemical composition data were generated with PROC MIXED of SAS 9.2 2008 (SAS Institute, year of publication), and the fixed effects included in the statistical model included treatments and measured parameters. Least square means were calculated for all the main and interactive effects, and when significant (P < 0.05) F values were observed, least squares means were statistically separated with t-tests PDIFF. The consumer evaluation data were subjected to the frequency and cross tabulation procedures of Descriptive statistics (IBM SPSS Statistics version 22, 2013) to compute frequencies of occurrence of each qualitative trait.

RESULTS AND DISCUSSION

Meat quality attributes of the sampled rump steak portions are presented in Table 1. The values for the meat colour traits scored between 34.44 and 35.73 for lightness, 16.78 and 17.82 for redness while yellowness values were found between 15.45 and 15.80 respectively (Table 1). The values are slightly lower for all the treatments indicating a paler colour of the meat. The paleness of the rump steaks from maize stover diet (A), sorghum stover diet(B) and commercial beef finisher(C) fed animals may be due to the influence of nutritional as well as genetic factors (Raes et al., 2003). The significant difference (P < 0.05) between treatments A, B and C were not determined within the meat colour traits. This may be due to the fact that the amount and redox state of myoglobin is responsible for the colour of the muscle surface (Byrne et al., 2000). Some studies have indicated that dark coloured muscles and oxidative fibres are experienced from free range feeding system and pale muscles also associated with feedlot system (Vestergaard et al., 2000). Variations in the levels of feeding and physical involvement among feedlot feeding system and pasture-fed animals influence changes in muscle colours and their metabolic behaviours (Vestergaard et al., 2000). In addition, pasture feeding will always have an upper effect on the condition of animal and its products because pasture production in the country (Botswana) is not really established or available since every farmer let his or her animals graze freely in communal areas without bearing any cost of pasture maintenance. Meat tenderness is the most important quality trait that consumers prefer and will pay more especially in European countries (Koohmaraie, 1988). A threshold shear force of 38.22 N has been used to distinguish intermediate and tender steaks (Delgado et al., 2005). A Warner-Bratzler shear force values of less than 31.36 N is considered very tender, 31.36 to 38.22 N

Table 2. Least square means for chemical composition (g/100g edible meat) of yearling Tswana steers` rump steaks fed maize stover diet, sorghum stover diet and commercial beef diet finisher.

Traits	Treatments				
	Maize stover	Sorghum stover	Commercial diet	S.E.M	P-Value
Crude Protein	19.21	19.59	20.59	1.059	NS
Moisture	69.76	69.67	67.02	1.802	NS
Total fat	7.71	4.64	8.42	1.348	NS

Each value is an average of nine observations; NS=Non significant (P > 0.05); S.E.M= standard error of mean.

being tender, 38.22 to 45.08 N being intermediate and more 45.08 being tough (Shackelford et al., 1991). In the current study shear force value was not affected by roughage source (P > 0.05) and the meat from all treatment groups was considered very tender with an average value of 18.10 N. The sorghum stover diet (B) fed animals numerically had relatively tenderer rump steaks than rump steaks from maize stover diet (A) fed animals since less force was used to penetrate or cut through the steaks. Overall tenderness can be improved by increasing of high-energy diets which influence the myofrillar fragmentation to be easier and increasing detectable connective tissue (Boleman et al., 1996).

After slaughter, glycogen is converted to lactic acid and there is reduction of muscle pH from neutral value of 6.56 at two hours postmortem to 5.48 at twenty-four hours postmortem (Byrne et al., 2000). The pH can also affect meat tenderness and pH of 5.48 – 5.89 is regarded as normal. The values for meat pH (rump steaks) from the three diet treatments are presented in Table 1, and range from 5.02 to 5.50. Some significant difference for muscle pH was noticed between treatments B and treatment C (P < 0.05). Nevertheless treatment A was not statistically different from treatment B (P > 0.05). The pH value of the commercial diet was lower than the normal pH range of 5.48-5.89. This is attributable to high energy density of the diet which resulted in more glycogen being available for conversion into lactic acid (Bello and Tsando, 2014; Li et al., 2014). Table 2 contains chemical composition for rump steaks (gluteus muscle) of steers which were fed different diets. The results include crude protein, moisture and total fat. The average crude protein levels found in this research work for treatments A, B and C were 19.21 g/100 g; 19.59 g/100 g and 20.59 g/100 g respectively (Table 2). There was no significant difference for crude protein across the three treatments (A, B and C) (P > 0.05). Treatment A (steaks from maize stover diet fed steers) was similar to treatment B (steaks from sorghum stover diet fed steers) in terms of crude protein P = 0.8014 while content of crude protein from treatment A showed some similarities with treatment C with p-value of 0.3654. The results also indicated that protein amount in treatment B did not differ significantly from treatment C (P = 0.5104). The values found for crude proteins are similar or slightly lower than those observed by Prado et al. (2009) and Williams 2007. This is in agreement with the previous study by Prado et al 2008a suggesting that genetic constitution does not change the crude protein percentage in beef animals. It was mentioned that there is very little variation of crude protein in beef chemical composition, approximately 21% regardless of physiological condition, breed, genotype and diet (Marques et al., 2006a; Padre et al., 2009a; Macedo et al., 2007,). Similar results were observed in another study by Patten et al., 2008 in which they found no difference in protein content. Therefore, treatment A, B and C were similar (P > 0.05) for mean percentage protein in rump steaks (Gluteus muscles) of feedlot-developed steers.

There were no significant differences observed in the moisture content between treatments A, B and C (P > 0.05). The moisture amount in this study has no variation with values such as 69.76, 69.67 and 67.02 g/100 g respectively Table 2. The values seemed to be slightly lower than those reported in previous studies (Prado et al., 2008a; Rotta et al., 2009; Delgado et al., 2005; Williams, 2007), who reported values ranging from 70.16 to 74.25%. However, the moisture content of this study is in accordance with that reported by Brown et al. (2007). The rump steaks from commercial diet(C) fed steers had the lowest numerical value for mean percentage moisture, however there was no significant difference in moisture content from rump steaks of treatment A and B (Table 2). Some research work had indicated that the variation in moisture levels can also occur due to the total lipid content in the muscle (Moreira et al., 2003; Rotta et al., 2009). The higher percentage of total lipids in the muscle is usually related to lower moisture content in the muscle (Prado et al., 2009). High total fat contents are reported in this study with values ranging between 4.64 and 8.42 g/100 g (Table 2). The increased content of total fat is normally associated with the lower moisture percentage by these treatment groups. There was no significant difference between treatments A, B and C (P > 0.05), however treatment B had the lowest numerical value which nearly differed from treatment C in total fat from rump steaks of yearling steers (P = 0.0589) (Table 2). It is worth mentioning that the average total fat content of the muscles observed here was moderately higher (>4%). These results are in line with those observed in gluteus medius in cow and beef muscles (Patten et al.,

Table 3. Sensory evaluation for rump steaks of yearling Tswana bulls fed maize and sorghum stover diets and commercial beef finisher diet.

Traits	Treatments					
	Maize stover diet		Sorghum stover diet		Commercial diet	
Flavour	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
Dislike	2	6	7	19	12	31
Like	36	94	31	81	26	69
Tenderness						
Tough	3	8	8	21	10	27
Tender	35	92	30	79	28	73
Moistness						
Dislike	8	21	7	18	13	34
Like	30	79	31	82	25	66
Appearance						
Dislike	5	13	11	29	14	37
Like	33	87	27	71	24	63
Over Impression						
Dislike	5	14	8	21	11	29
Like	33	86	30	79	27	71

2008; Brown et al., 2007). All these researchers suggested that percentage moisture decreases as fat percentage increases with higher marbling scores. The relationship between moisture and fat content was also observed by Patten et al. (2008) in which they revealed that the amount of intramuscular fat is a major contributor to the difference in percentage of moisture and fat content (Table 2, 69.17, 4.64 vs 67.02, 8.42), as an increase in marbling increases fat content and eventually decrease water content.

The panelists rated sensory evaluation attributes for the rump steaks of Tswana feedlotted yearling steers from different treatments of diets in terms of flavor, tenderness (texture), moistness (juiciness), appearance and overall impression (Table 3). The sensory results of this study revealed that 84% of the panelists ranked the flavor of rump steaks (like moderately to like extremely) from maize stover diet treatment, 81% of the consumers rated steaks from sorghum stover diet treatment while 69% of the panelists score steaks from commercial beef finisher diet treatment ranging from like moderately to like extremely showing lower preference for the control treatment. Low rating of commercial diet (C) is attributable to high fat content as reflected in Table 2. The results of this study are in agreement with earlier studies by Warris (2000), who indicated that meat flavor could be improved to a greater height through potential dietary manipulations. Resconi et al. (2010) revealed that beef flavour intensities are influenced by the content of the diets. In another study (Resconi et al., 2009) it was reported that species-specific flavours were associated with the concentrates proportion in the diet of farm animals. Nevertheless, there are other factors such as pre-slaughter stress and ageing that influence the meat flavor in various ways (D`Souza et al., 1998; Kontsidis et al., 2003). Flavour especially of roasted meat is more associated with the typical maillard reaction products such as furanes, thiazoles, pyrroles and pyrazines (Raes et al., 2003). Both dry and wet aging are responsible for the development of meat flavor in farm animals (Miller et al., 1997; Campbell et al., 2001).

Ninety-two percent of the panelists rated rump steaks from yearling Tswana steers finished from maize stover diet to be just about right to much too tender (Table 3). The rankings by the respondents were followed by 79% from sorghum stover diet finished animals meanwhile commercial diet finished animals were rated the least (73%). The study indicated that most of the respondents preferred most or favored the rump steaks from maize stover (A) finished animals and the least preferred rump steaks were from commercial beef finisher (C) diet animals. Studies by Raes et al. (2003) stated that assessment of taste panel tenderness seemed to be associated with collagen content. The resistance of collagen and myofibrillar to shearing is determined by the heat treatment as they vary for taste panel than firmness testing evaluations (Raes et al., 2003).

In terms of moistness (juiciness), the consumers rated

the rump steaks from sorghum stover diet (B) finished animals to be more juicy (82%) falling between like moderately and like extremely. Juiciness is usually influenced by intramuscular fat (marbling). The rankings were followed by maize stover diet (A) finished animals at 79%. Nevertheless the rump steaks from commercial beef finisher diet were ranked less juicy with only 66% (Table 3) suggesting that the commercial diet was associated with the driest rump steaks cuts. It was reported in some research work that the whole variation found in juiciness depends on both biophysical-biochemical state of water in the meat and cook loss; particularly water distribution and motility which play a vital role in meat juiciness (Toscas et al., 1999). Moreover, meat juiciness is also influenced by low quality protein diets resulting in slightly drier meat (Ngapo et al., 2003).

The sensory panelists indicated that in terms of appearance attribute, they preferred rump steak cuts colour from maize stover diet (A) finished animals ranging from like moderately to like extremely (89%). However, the rump steak cuts from sorghum stover diet (B) finished animals were moderately preferred (71%) while the least rated rump cuts were from commercially beef finished diet (C) scoring only 63% (Table 3). It was noted that most of the cooked beef colour ranged from purplish-brown, light and dark brown colour as result of Maillard reaction. Lanari et al. (1995) stated that consumer assessment of meat quality depends on the perception of meat colour. Moreover the colour perception is determined by the observer of the meat product and therefore the background value of relative colour measurements should be known to the subjective judgment of acceptable colour (Van Oekel et al., 1999). Research showed that colour is an important indicator of quality of cooked meat; as such the appearance of meat influences its acceptance by the consumers (Northcutt, 1997).

In terms of overall acceptability, steers fed maize stover diet (A) were well received by the panelists from like moderately to like extremely (86%) followed by 79% rankings from sorghum stover diet (B) finished animals while steak cuts from commercial beef finisher diet (C) were the least ranked from like moderately to like extremely. It is very important for the meat industry to produce beef of acceptable quality in order to satisfy consumers` preference and needs at the least costs (National cattlemen`s Beef association, 2005). The respondents had indicated that Tswana beef finished from maize stover diet (A) were more palatable than the ones finished from sorghum stover diet (B) and commercial beef finisher diet (C) respectively. Therefore the overall acceptability ratings were directed towards maize stover diet (A) finished steak cuts except for moistness (juiciness) attribute where the highest rankings were obtained from sorghum stover diet (B) finished animals` steak cuts.

Conclusion

The current study indicated that differences in colour traits and tenderness of meat from yearling Tswana steers were less evident. However, the muscle pH of sorghum stover diet finished animals was significantly different from commercial diet finished animals. Consumers ranked higher meat from animals finished on maize stover diet in attributes of flavor, tenderness, and appearance except in moistness (juiciness) which was rated the best from animals finished with sorghum stover diet. Therefore, the sensory result suggested that feeding steers with maize stover had no detrimental effects and has also increased sensory attributes on meat quality. However, the chemical composition of the meat from the current study was not influenced by the roughage type.

Conflict of Interests

The authors have not declared any conflict of interests.

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Fertility and Hatchability Performance of Pure and Crossbred Indigenous Chicken Strains in the High Rainforest Zone of Nigeria

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The effect of strains on fertility, hatchability, and embryo mortality of indigenous chicken reared in the high rain forest zone of Nigeria was investigated. In this investigation, indigenous chicken with normal feathered phenotype, naked neck, and frizzle feathered phenotype which consisted of 10 cocks and 35 hens as the parents were used. They were put in 7 breeding groups: (1) Normal feathered cock with normal feathered hen (*na* × *na*); (2) Naked neck cock with naked neck hens (*Na* × *Na*); (3) Frizzle feathered cock with frizzle feathered hens (*Ff* × *Ff)*; (4) Frizzle feathered cocks with normal feathered hens (*Ff* × *na*); (5) Naked neck cock with normal feathered hens (*Na* × *na*); (6) Normal feathered cock with naked neck hens (*na* × *Na*), and (7) Normal feathered cock with frizzle feathered hens (*na* × *Ff*). The hens were five in each group and artificial insemination of the desired cock for each group was carried out twice a week before eggs were collected for incubation. Results from data analysis showed no significant difference (P>0.05) in fertility and embryo mortality within breeding groups. Egg fertility ranged from 58.82% for *Na* × *na* to 91.38% for *Ff* × *na* strain. Significant strain effect (P<0.05) was recorded for hatchability with highest value of 86.36% for *na* × *na* and the least value of 55.56% for *Na* × *Ff* strain. The *Ff* × *Ff* also had the highest embryo mortality of 34.36%. It was concluded that continuous reduction in the population of indigenous chicken with major gene of frizzling and naked neck may be attributed to greater loss of the chicks before hatching. There is need for adequate conservation of these rare genes in order to prevent them from going to extinction.

Key words: Hatchability, pure, crossbred chicken, normal feather, frizzle feather, naked neck, embryo mortality.

INTRODUCTION

Indigenous chicken constitutes 80% of the 120 million poultry type raised in the rural areas in Nigeria (RIM, 1992). The growth rate of indigenous genotype chickens is generally much slower than that of commercial broilers (Pym et al., 2006). While broilers under typical confinement rearing may reach 2.0 kg live weight at five weeks of age, indigenous-breed male birds often weigh no more than 1.0 kg at 20 weeks (FAO, 2010).

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This is a reflection of true genotype differences, but also of the rearing environment, in which feed quantity and quality is the major factor. Despite their lower productivity, in the village environment, the indigenous genotype birds have a number of advantages: they are self-reliant and hardy birds with the capacity for better resistance to diseases and parasites, ability to withstand harsh weather condition and adaptation to adverse environment. They are known to possess qualities such as the ability to hatch on their own, brood and scavenge for major parts of their food and possess appreciated immunity from endemic diseases (Ajayi, 2010). Their products are preferred by the majority of Nigerian because of the pigmentation, taste, leanness and suitability for special dishes (Horst, 1989). Their meat and eggs are also generally preferred to those from commercial birds, not only by rural communities but also often by urban dwellers (Pym et al., 2006). One of the important reasons to conserve local chicken genetic resources is to conserve the genetic variation within and between local breeds. Indigenous chicken also possess high genetic diversity for many traits and are therefore valuable genetic resources for present and future generations (Gueye, 2009; Dana et al., 2010). The future improvement and sustainability of local chicken production systems is dependent upon the availability of this genetic variation (Benítez, 2002). Fertility and hatchability are interrelated heritable traits and varies among breeds, varieties and individuals within a group. Fertility and hatchability parameters are most sensitive to environmental and genetic influences (Stromberg, 1975). There is a relationship between the number of spermatozoa inseminated and embryo survival (Eslick and McDaniel, 1992). They concluded that embryo mortality increased significantly with decreased number of inseminated spermatozoa. Under hatchability, there are many factors contributing to the failure of a fertile egg to hatch which include lethal genes, insufficient nutrients in the egg, and exposure to conditions that do not meet the needs of the developing embryo (Peters et al., 2008; King'ori, 2011). Fertility refers to the total number of incubated eggs that are fertile, while hatchability refers to set eggs that hatched. Limited information abound on the interactive effect of sire and dam of the Nigerian indigenous chicken, thus this study was designed to elucidate the fertility and hatchability of the indigenous strains in their pure and crossbred state.

MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm, University of Port Harcourt, Port Harcourt (5.14'N and 6.44'E). The area lies in the South-South zone of Nigeria with a prevailing high average monthly rainfall ranging from 2400 to 3600 mm. The average temperature of the area ranged from 26 to 28.6°C during the rainy season and between 32 and 34°C during the dry season; although mild period occasionally prevailed. The relative humidity ranged from 70 to 90% and 4.8 to 6.5 h, respectively. Port Harcourt is situated at 4.78° North latitude, 7.01° East longitude and 468 m elevation above the sea level.

The breeding stocks were selected from the pool of 108 chicken hatched from 208 fertile eggs obtained from the improved indigenous chickens stocked by the Federal University of Agriculture (FUNAAB), Abeokuta Nigeria. Fifteen 15 normal feathered, 10 naked neck and 10 frizzle feathered hens and 10 cocks were selected as parents of the next generation. They were distributed into 7 breeding groups: Normal feathered cock with normal feathered hen (*na* × *na*); Naked neck cock with naked neck hens (*Na* × *Na*); Frizzle feathered cock with frizzle feathered hens (*Ff* × *Ff)*; Frizzle feathered cocks with Normal feathered hens (*Ff* × *na*); Naked neck cock with normal feathered hens (*Na* × *na*); Normal feathered cock with naked neck hens (*na* × *Na*); and Normal feathered cock with frizzle feathered hens (*na* × *Ff*).

The hens were five in each group and artificial insemination of the desired cock for each group was carried out twice a week before eggs are collected for incubation. Fertilized eggs were collected from 15 normal feathered, 10 frizzled and 10 naked neck hens of 30 weeks old for a period of four weeks. A total of 475 eggs were collected from all the birds for the period. Birds were inseminated with semen collected by abdominal massage as described by Hafez (1978). Insemination was done twice a week and eggs were collected daily from the hens. The eggs were stored at a temperature of 10°C, pedigreed by sire and dam lines by the use of a marker. The eggs were incubated and hatched with electrically heated (1000 egg capacity) incubator at a local hatchery (Gofon Veterinary Services) Owerri, Imo State. The incubation temperature and relative humidity were 37.5°C and 62.50%, respectively. Candling box measuring 0.44 × 0.44 × 0.44 m fitted with two 60 watt incandescent tungsten bulbs was used for candling of eggs. All infertile eggs and eggs with dead embryo were removed on the 21st day and chicks hatched were also recorded. The percentage of dead embryo was calculated as number of dead embryo divided by total number of eggs set. The fertility and hatchability percentage were calculated as follows:

% Fertility = (Total no. of fertile eggs/Total no. of egg set) × 100

% Hatchability = (Total no. of hatched eggs/Total no. of fertile eggs) × 100

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% Embryo Mortality = (Total no. of Dead Embryo/Total no. of eggs set) × 100

The chicks were wing tagged at one day old and brooded in a deep litter house from 0 to 8 weeks age under standard management.

Data analysis

Data collected from the study was subjected to analysis of variance using the Generalized Linear Model (GLM) of Statistical Analysis Systems (SAS), 1999 using the sire/dam genotypes as the source of variation and means were separated using Duncan multiple range test of the same package. The linear model is stated as:

$Y_{ijkl} = \mu + Si + Dj + (SD)ij + Eijkl$

where Y_{ijkl} = dependent variable, μ = overall mean, S_i = effect of the i^{th} sire (I = 1,2,3), D_j = effect of the j_{th} dam strain (j = 1,2,3), $(SD)_{ij}$ = effect of the interaction between sire and dam genetic group, and E_{ijkl} = random error normally distributed with zero mean.

RESULTS AND DISCUSSION

The result from this study revealed significant sire/dam

Table 1. Sire/dam interaction effect on egg fertility, hatchability and embryo mortality of Nigerian indigenous chicken strains

Sire/Dam interaction	Egg set	Fertilized eggs	Unfertilized eggs	Hatched eggs	% Fertility (%)	% Hatchability (%)	% Embryo mortality (%)	Average chick weight at hatching (g)
Ff × *Ff*	55	42	6	25	76.78±2.7^{b}	62.09±8.9^{bc}	34.36±3.92^{a}	31.82±0.89
Ff × *na*	92	84	8	58	91.37±0.5^{a}	69.16±2.5 ^{b}	21.09±9.22^{a}	33.98±0.53
na × *na*	178	129	32	110	71.81±8.6^{b}	86.36±9.4^{a}	13.36±5.16^{b}	34.13±0.47
na × *Ff*	13	9	4	5	69.23±8.6^{b}	55.56±0.0^{c}	0.00±0.0^{c}	32.50±1.19
na × *Na*	17	11	6	8	64.23±0.0^{b}	72.73±0.0^{b}	17.64±0.0^{b}	28.13±1.40
Na × *Na*	69	56	10	48	81.74±9.8^{ab}	66.90±3.2^{b}	30.95±11.3^{a}	34.42±0.78
Na × *na*	51	40	21	25	73.82±0.0^{b}	63.33±0.0^{b}	9.80±0^{bc}	30.32±2.11
Overall	475	371	87	279	77.19±3.9	71.01±4.5	21.78±3.83	32.58±0.95

^{abc}Means within the same column carrying different superscripts differ significantly (P<0.05). *Ff*: Frizzle feather, *Na*: Naked neck, *na*: normal feather

interactive effect for fertility and hatchability of strains involving pure and crossbred indigenous chicken (Table 1). Fertility and hatchability is said to be environmentally influenced. Fertility and hatchability are major parameters of reproductive performance which are most sensitive to environmental and genetic influences (Stromberg, 1975) Fertility was the highest for Ff × na strain (91.37% and least for na × Na -64.23%). Pure frizzle feather and naked neck strains also recorded higher fertility than the pure normal feathered chicken. Fertility was 4.97% higher in frizzle gene and 9.93% higher in the naked neck than their normal feathered counterpart. This finding is consistent with earlier reports (Horst, 1989; Peters et al., 2008). This may be due to the superiority of the adaptive genes of frizzling and naked neck genes and the fact that the frizzle gene produced 13.98% more semen and the naked neck gene also had 18.68% higher concentrated semen than the normal feathered gene (Ajayi et al., 2011). Hatchability percentage on the other hand was the highest in the pure normal feathered chicken with value of 86.36%, whereas lower values of 62.09 and 66.90% was recorded for pure frizzle and naked neck strains, respectively. The crossbred strains ranged between 55.56 and 72.73% in hatchability percentage. This result is consistent with the findings of Peters et al. (2008) who reported the highest hatchability for normal feathered genetic group followed by frizzle and naked neck genetic group with corresponding values of 89.75, 84.62 and 82.63%, respectively. Many factors may have contributed to the failure of fertile eggs to hatch which include lethal genes, insufficient nutrients in the egg and exposure to conditions that do not meet the needs of the developing embryo (King'ori, 2011).

The pure normal feathered genetic group also had the least embryo mortality (13.65%) when compared with the pure frizzle and naked neck genetic groups (34.36% versus 30.95%) and the crossbred involving these major genes. According to Merat (1986), the increase in embryonic mortality up to 10% found in pure strain Na/Na and to a large extent Na/na put them at a disadvantage to the normal feather birds. The low hatchability and high embryonic mortality as observed in pure frizzle and the naked genes in this study may be the reason for continuous reduction of chicken population among poultry birds. There is however no significant difference in chick weight at hatching for both pure and crossbred chicken. Chick weight ranged from 28.13 g for na × Na to 34.13 g for na × na strain. Sire and dam genotypes showed no significant difference (P>0.05) for percent fertility and hatchability of eggs (Table 2). This result contradicts the reports of Peters et al. (2008) who found significant difference between sire and dam genotypes. Embryo mortality and chick weight at hatching were not also significant (P>0.05). The difference found in the two studies may be attributed to larger number of birds used in the former than the latter and also to the different environmental management of the birds.

In conclusion, this study revealed that indigenous pure and crossbred frizzle and naked neck chicken had reduced fertility and hatchability and also higher embryo mortality than their normal feathered counterpart. This may be the reason for the continuous reduction of their population among poultry birds. There is need for their adequate conservation so that the frizzle and

Table 2. Sire/Dam genotype effect on fertility, hatchability and embryo mortality on Nigerian indigenous chicken strains.

Sire genotype	Egg set	Fertilized Fertile eggs	Unfertilized Infertile eggs	Hatched eggs	% Fertility (%)	% Hatchability (%)	% Embryo mortality	Chick weight at hatching (g)
Ff	147	126	14	83	84.08±6.3	65.62±7.1	27.73±5.37	32.92±0.98
Na	120	86	31	61	76.01±9.0	71.01±10.2	25.66±9.58	32.38±0.56
na	208	140	42	123	69.87±4.9	77.47±7.9	11.55±4.12	31.58±0.75
Dam genotype								
Ff	68	51	10	30	74.89±8.7	60.46±6.5	25.77±9.02	32.56±0.91
Na	86	57	16	44	77.48±8.1	68.36±9.4	27.63±8.66	32.18±0.69
na	321	213	61	193	78.34±5.9	78.56±6.8	16.17±4.38	33.23±0.53

Ff: Frizzle feather, *Na*: Naked neck, *na*: normal feather.

naked neck chicken will not go into extinction.

Conflict of interests

The authors have not declared any conflict of interests.

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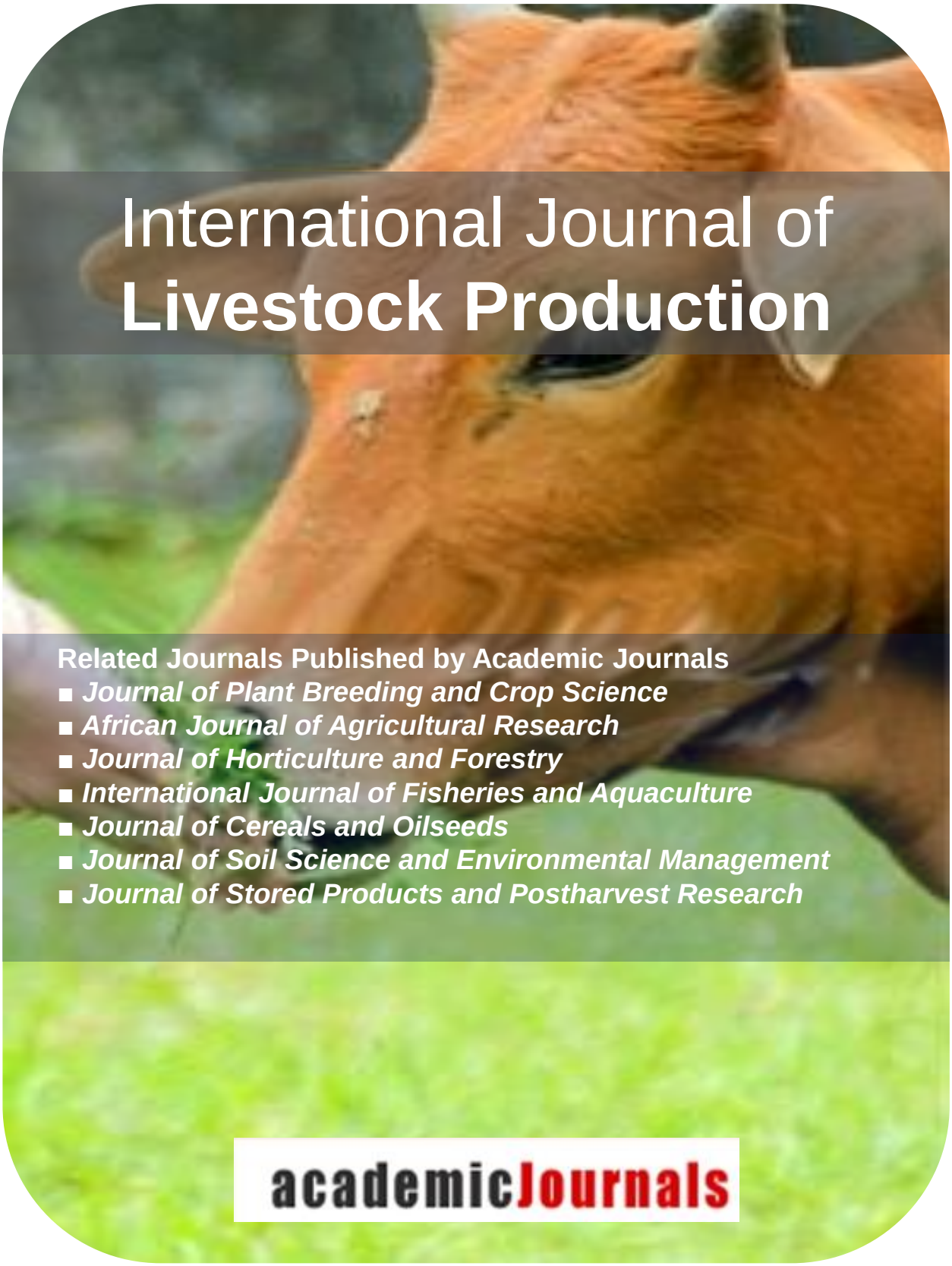

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