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REGULAR ARTICLES

Cattail (*Typha domingensis*) silage improves feed intake, blood profile, economics of production, and growth performance of beef cattle

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Abstract

Sixteen Rahaji breed beef cattle (112.00 ± 0.15 kg body weight (BW)) were randomly assigned to one of four rations differing in the degree of substitution of sorghum straw with Cattail (*Typha domingensis*) silage. Growth performance, feed intake, blood profile, and economics of production were evaluated. Completely randomized design was used, and the feeding trial lasted for 42 days. Cattle were fed a total mixed ration of roughage:concentrate (400:600) g/kg dry matter and gamba hay free choice. The control diet (T0) contained 400 g/kg sorghum straw, expressed on a dry matter basis (DM). For additional treatments, *Typha* silage (TS) was included at 100 (T10), 200 (T20), and 300 (T30) g/kg of the mix replacing an equal DM weight of sorghum straw. Growth rate was similar ($P > 0.05$) regardless of the TS level. DM (5160.77–5524.96 g/d) and crude protein (846.36–955.82 g/d) intakes were higher ($P < 0.05$) in T20 and T30 diets, while the acid detergent fiber intake (471.27–512.46 g/d) reduced ($P < 0.05$) in TS-based diets. Red blood cell concentrations of cattle fed TS-based diets increased ($P < 0.05$). The mean corpuscular hemoglobin concentrations of cattle fed T20 diet decreased ($P < 0.05$) in comparison with the control. Sodium and albumin concentrations were higher ($P < 0.05$) in cattle fed TS-based diets. Total cost of feeding ($ 49.60–61.62) decreased ($P < 0.05$) in TS-based diets, while the gross benefit of cattle fed 300 g/kg TS diet ($ 74.98) was enhanced relative to cattle fed T0 and T10 diets. TS can be considered a new resource of feed for cattle.

Keyword Roughage. Concentrate. Silage. Cattle. *Typha domingensis*

Introduction

The predominant system of beef cattle rearing in Nigeria is extensive management where the animals are allowed to obtain their nutrients by grazing pastures and consuming low-quality crop residues (Wilkinson and Rinne, 2018). Recently, the restriction of movement of the herders as a result of COVID-19 has brought a tremendous negative impact on the well-being of animals and food security in Nigeria. Thousands of herders are trapped in different areas of the Sahel region, resulting in a drastic price reduction of the animals and loss of profit for the herders (Badu et al. 2020). Also, during the dry season, the performance and productivity of animals decrease due to the limited quality and quantity of feed supplies (Gashaw and Defar, 2017). Therefore, there is a need to design measures that would improve feed intake, utilization, and overall performance of ruminants through feed supplementation (Okunade et al. 2016). Olafadehan et al. (2016) noted that concentrate feedstuffs are incorporated into ruminant diets in order to improve nutrient intake and the efficiency of feed utilization. The authors, however, observed that high cost of feed ingredients needed for concentrate formulation highlights the need for less expensive and locally available feed ingredients.

Cattail (*Typha domingensis*) is an invasive plant which is a major problem in the Hadejia Valley Irrigation Scheme (HVIS) in northern Nigeria where economic activities, health, and well-being of local communities are threatened

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by this plant (Lado et al. 2016). *Typha* is a rapidly growing grass, which has taken over thousands of hectares of irrigable lands making cropping and fishing activities impossible most especially for rice farmers in the area. It is also known to block water ways and harbor dangerous animals such as snakes (Lado et al. 2016). Anjana and Matai (1990) analyzed the nutritive value of *Typha* plant in relation to its utilization as animal forage. The authors reported that *Typha* plant contained 14.4% dry matter, 8.70% crude protein, 9.50% ash, 3.50% ether extract, 28.10% crude fiber, and 50.2% nitrogen free extract. *Typha* plant contained 25.8% dry matter, 89.8% organic matter, 8.84% crude protein, 67.9% neutral detergent fiber, 41.9% acid detergent fiber, and 2.00% ether extract (De Evan et al. 2019). Wilkinson and Rinne (2018) observed that inadequate feedstuffs availability in the tropical environment makes silage an important feed supplement for grazing ruminants. Also, Abdullahi et al. (2016) noted that ensiling of crop residues, forages, and their by-products under anaerobic fermentation in the tropics has made regular feed supply possible during the dry season. We propose that *Typha* silage (TS) might be used in ruminants feeding to increase the sustainability of livestock farms, but its nutritional value and effect on the performance of ruminants need to be assessed. This study was designed to evaluate the effects of TS as substitute for sorghum straw on feed intake, blood profile, economics of production, and growth performance of beef cattle.

Materials and methods

Study area

The research was carried out at the Ruminant Unit of the Teaching and Research Farm of the Department of Animal Science, Federal University, Gashua, Yobe State, Nigeria. The hottest months are March and April with temperature ranges of 38–40 °C. In the rainy season, June to September, temperatures fall to 23–28 °C, with rainfall of 500 to 1000 mm (Climatemp 2020). The research area, which has been invaded by uncontrolled growth of *Typha* grass, covers the Hadejia Valley Irrigation Scheme (HVIS) Jigawa State, Nigeria.

Silage preparation procedures

Boot stage *Typha* grass of less than 1 m tall was harvested at HVIS. The grasses were wilted to an approximate moisture content of 60–65% by drying the samples outdoors on top of black plastic for 18 h following the protocol developed by Sale et al. (2018). After wilting, the samples were chopped to pieces of 2.3-cm length using a locally constructed chopping machine (VTQS-0.4 Model, 953*344*800 mm, NAERLS, Nigeria). Thereafter, 40 L and 5 kg of molasses and urea respectively were dissolved in 250 L of water solution and added to 1 ton of chopped *Typha* and mixed thoroughly according to the procedures of Musa et al. (2020). This was done to improve the nutritive value of *Typha* grass. Samples were then packed in thick polythene bags and pressed thoroughly to eliminate air and closed tightly for anaerobic fermentation. The silage density was 205 kg DM/m^3. After 90 days of ensiling, the silage was harvested and aerated overnight under shade to reduce or eliminate the volatile ammonia gas that causes ammonia toxicity and pungent smell that may put off the animals from consuming or cause ammonia toxicity if offer immediately after ensiling (Olafadehan et al. 2016).

Experimental procedure, design, and management of experimental animal

Sixteen healthy Rahaji beef cattle weighing 112.00 ± 0.15 kg BW, after veterinary inspection, were randomly distributed into four dietary treatments with four replicates per treatment following a completely randomized design. Each cattle formed an experimental unit. Animals were housed individually in a well-ventilated open-sided ruminant pen (2 m × 5 m) to prevent them from harsh weather. All the cattle were treated with antibiotics (oxytetracycline at 1 mL/10 kg BW) and (ivermectin at 1 mL/50 kg BW) 2 weeks before the study began. The animals were fed about 2.24 g/kg roughage-concentrate mixed ration per day (DM), which is 2% of their BW with concurrent adjustments as BW increased. Animals were fed twice daily at 08:00 h and 13:00 h in equal proportion at the two feeding periods. Water and trace-mineral blocks were made available ad libitum. The experimental diets were supplied to the experimental animals in plastic rubber containers. The initial weights of the animals were taken before the onset of the experiment. Thereafter, weight change was measured weekly. The feed refusals were removed daily before fresh feeds were given. Dry matter and nutrient intakes were determined. The experiment lasted 42 days after a preliminary adaptation period of two week.

Measurement and formulation of experimental diets

The control diet (T0) was formulated using locally available feed ingredients commonly used by cattle herders in the study area. They composed of cowpea husk (170), wheat bran (200), groundnut cake (200), sorghum straw (400), bone meal (7.50), ruminant premix (2.50), and salt (20) g/kg DM. Increasing amounts of 100 (T10), 200 (T20), and 300 (T30) g/kg TS were added replacing equal amounts of sorghum straw on a dry weight basis and then mixed thoroughly with other feed ingredients to form roughage-concentrate mixed ration. This was done manually every day for the period of 42 days which the trial lasted. Each animal was offered the roughage-concentrate mixed ration and gamba (*Andropogon gayanus*) hay free choice. The nutrient composition of *Typha* grass, *Typha* silage, sorghum straw, and gamba hay is shown in Table 3, while the composition of ration ingredients is shown in Table 4.

Blood sample collection and analyses

On the last day of the experiment, blood samples were collected from each cattle through the jugular vein puncture using hypodermic syringes into Vacutainer tubes (Becton Dickinson, Franklin Lakes, NJ, USA). Blood samples meant for hematological analysis were collected into plastic bottles (5 mL) containing ethylene diamine tetra-acetic acid (EDTA), while other samples used for serum determination were collected into plastic bottles (5 mL) without EDTA for serum analysis. Serum was obtained by centrifugation at 3,000 revolutions per minute for 10 min at ambient temperature of 28 °C and stored at -20 °C in a deep freezer until required for the serum tests. The procedures earlier described by Dacie and Lewis (2001) was used to determine packed cell volume (PCV) concentration, while red blood cell (RBC) count was determined using the improved Neubauer hemocytometer counting chamber (BS748:1982; British Standard Institution, London, UK) after appropriate dilution. Also, the formula described by Dacie and Lewis (2001) was used to calculate mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), and mean corpuscular volume (MCV) using the values earlier determined for RBC and PCV. Serum total protein and albumin values were determined using the BCG (bromocresol green) method as described by Peters et al. (1982). Serum glucose, urea nitrogen, and cholesterol constituents were determined spectrophotometrically (Thermo Fisher Scientific Inc., Madison, Wisconsin, USA) using commercial reagent kits (United Diagnostic Industry, Dammam, Saudi Arabia) as described by Coles (1986). Serum potassium, sodium, and phosphate were determined using appropriate commercial kits (Randox Laboratories, UK) as described by Reitman and Frankel (1957) with modifications.

Chemical analysis

Samples of *Typha* grass, TS, sorghum straw, and other feed ingredients were taken to the laboratory, dried individually in an air-draft oven at 60 °C for 96 h, ground separately to pass through a 1 mm sieve in a Wiley mill, and sampled for chemical analysis using the standard methods of the Association of Official Analytical Chemists (AOAC, 2006). Each analysis was done in triplicate. Dry matter was determined after oven-drying the samples at 100 °C for 24 h. Fiber fraction analysis including neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) was done using the ANKOM fiber analyzer as described by Van Soest et al. (1991). NFC% = 100 − (NDF% + CP% + EE% + CA %) is according to Weiss et al. (1992). Metabolizable energy (MJ/Kg DM) is calculated by the equation proposed by Robinson et al. (2004): ME = 14.03 − (0.01386 × CF %) − (0.1018 × Ash %). Where EE = ether extract, ADF = acid detergent fiber and ADL = acid detergent lignin. Samples were stored at -20 °C until the analyses. The WSC of samples were determined by phenol sulfuric acid method (Dubois et al. 1956). Concentrations of volatile fatty acids (VFAs) in the rumen fluid were analyzed by gas chromatography and auto-analyzer as described by Zijlstra et al. (1977). Analysis was done at the Department of Animal Science Laboratory, Ahmadu Bello University, Nigeria.

Cost benefit analysis

The variable cost of feeding the cattle including the costs of harvesting and processing the *Typha* silage were all regarded as the cost of the feeds; therefore, the remaining costs involving capital investment, labor, and housing were the same for all the treatments.

Data analysis

Data were subjected to analysis of variance (ANOVA) for a complete randomized design, with a model that included the diet as treatment effect, using Statistical Analysis Software (SAS, 2015). Means were separated using Duncan's multiple range test at the level of $P \leq 0.05$.

The statistical model used was as follows:

$Y_{ij} = \mu + TS_i + e_{ij}$
Y_{ij} = Individual observation
μ = population mean
TS_i = effect of i^{th} *Typha* silage diets
e_{ij} = random error

Results

Table 1 shows the chemical composition of *Typha* grass, *Typha* silage, sorghum straw, and gamba grass (g/kg dry matter), while Tables 2 and 3 shows the organic acid concentration (% DM) and pH of *Typha* grass silage. Table 4 shows the performance characteristics, feed, and nutrient intake of beef cattle fed TS-based diets. Growth

Table 1 Chemical composition of *Typha* grass, *Typha* silage, sorghum straw, and gamba grass (g/kg dry matter)

Nutrients	*Typha* grass	*Typha* silage	Sorghum straw	Gamba hay[1]
Dry matter	386	565	956	981
Organic matter	903	921	963	955
Crude protein	66.1	68.3	33.7	62.0
Ether extract	8.00	9.70	2.00	22.0
Total carbohydrate	821	843	927	871
Non-fiber carbohydrate	150	331	323	100
Acid detergent fiber	186	309	326	428
Neutral detergent fiber	680	512	604	771
Acid detergent lignin	56.0	57.2	69.4	73.0
WSC	100	15.4	13.8	22.5
Soluble *N*, % of *N*	48.0	41.7	29.6	39.9
Metabolizable energy (MJ/Kg DM)	13.5	12.5	11.5	9.23

[1]Muhammad et al. (2009). *ND* Not determined

Table 2 Organic acid concentration (% DM) and pH of *Typha* grass silage

Parameters	Concentration
pH	4.15
Lactic acid	8.50
Acetic acid	2.78
Propionic acid	0.10
Butyric acid	0.25
Isobutyric acid	ND
Isovaleric acid	ND
Ammonia nitrogen/total nitrogen	11.3
Soluble nitrogen/total nitrogen	41.7

ND Not determined

Table 3 Ingredient and chemical composition of the diets

Ingredient, g/kg DM	T0	T10	T20	T30
Cowpea husk	170	170	170	170
Wheat bran	200	200	200	200
Groundnut cake	200	200	200	200
Sorghum straw	400	300	200	100
Typha silage	0	100	200	300
Bone meal	7.50	7.50	7.50	7.50
Ruminant pre-mix[1]	2.50	2.50	2.50	2.50
Salt	20	20	20	20
Total	1000	1000	1000	1000
Chemical composition				
Organic matter	908	913	916	919
Crude protein	164	171	172	173
Ether extract	9.40	9.60	10.2	10.4
Neutral detergent fiber	309	302	302	301
Acid detergent fiber	99.3	96.0	88.9	85.3
Non- fiber carbohydrate	515.55	514.90	522.46	532.16
Metabolizable energy (MJ/kg DM)	10.27	10.36	10.51	10.56

[1]Ruminant pre-mix (Nutristar International, Cergy-Pontoise, France) 1 kg contains: vitamin A 5 000 000 IU, vitamin D3 1 000 000 IU, vitamin E 10 000 µg, choline chlorides 4 000 µg, manganese 25 000 µg, copper 2 000 µg, zinc 10 000 µg, selenium 0.200 µg, cobalt 0.250 µg, iron 25 000 µg, iodine 0.5000 µg, phosphorus 15 000 µg, antioxidant 11 200 µg

(T0 = 0% *Typha*, T10 = 10% *Typha*, T20 = 20% *Typha*, T30 = 30% *Typha*)

performance parameters were similar ($P > 0.05$) regardless of the amount of *Typha* silage in the diets. The DM and CP intakes were higher ($P < 0.05$) in T20 and T30 diets, while the acid detergent fiber intake reduced ($P < 0.05$) TS-based diets.

Table 5 shows the results of blood indices of beef cattle fed TS diets. The RBC concentrations of cattle fed TS diets were higher ($P < 0.05$), while cattle fed only T30 diet had a higher MCV than the control ($P < 0.05$). For the MCHC, all the TS-based diets except for T20 diet were higher ($P < 0.05$) compared to the control diet. Also, serum potassium and urea nitrogen concentrations were higher ($P < 0.05$) in T20 and T30 diets compared to the control diet. Concentrations of serum sodium and albumin increased ($P < 0.05$) in TS-based diets.

Cost benefit analysis (Table 6) shows that the total cost of feeding decreased ($P < 0.05$) in TS-based diets, while gross benefit of T20 and T30 diets were similar ($P > 0.05$). It was however enhanced in T30 relative to T0 and T10 ($P < 0.05$).

Discussion

Gamba grass had the highest DM of all the forage crops, followed by sorghum straw; lowest DM was recorded against *Typha* grass. All the grasses used in this study will give good quality silage. Ward et al. (2001) reported that

Table 4 Performance characteristics, feed and nutrient intake of beef cattle fed *Typha* silage based diets

Items	Typha silage inclusion level (g/kg)				SEM[1]	*P* value
	T0	T10	T20	T30		
Initial weight (kg)	110.75	114.00	112.25	112.50	1.20	0.374
Final weight (kg)	123.17	129.33	127.25	127.51	2.05	0.059
ADWG (kg/d)	0.31	0.37	0.36	0.36	0.04	0.268
FCE	16.65	14.19	15.11	15.35	1.08	0.062
Feed intake (g DM/day)						
Hay intake, g/d	1995.59	1988.42	1994.75	1986.77	14.91	0.677
Roughage-concentrate, g/d	3165.18[d]	3250.92[c]	3445.95[b]	3538.19[a]	24.08	<.001
Dry matter, g/d	5160.77[b]	5249.35[b]	5440.70[a]	5524.96[a]	30.30	<.001
Nutrient intake (g DM/day)						
Crude protein	846.36[b]	897.64[b]	935.80[a]	955.82[a]	18.53	<.001
Acid detergent fiber	512.46[a]	503.94[ab]	484.10[bc]	471.27[c]	5.32	0.002
Neutral detergent fiber	1594.67	1585.30	1642.88	1663.01	32.31	0.734
Non-fiber carbohydrate	2661.30	2702.88	2842.18	2940.16	142.75	0.152

SEM[1] pooled standard error of mean (T0 = 0% *Typha*, T10 = 10% *Typha*, T20 = 20% *Typha*, T30 = 30% *Typha*) [abc]Different superscripts in the same row are significantly different ($P < 0.05$)

ADWG average daily weight gain, *FCE* feed conversion efficiency (dry matter intake/ADWG)

Table 5 Blood profiles of beef cattle fed *Typha* silage based diets

Hematological indices	Typha silage inclusion level (g/kg)				SEM[1]	*P value*
	T0	T10	T20	T30		
PCV (%)	29.50	36.00	36.00	37.50	3.97	0.080
RBC ($\times 10^{12}$/L)	3.60[b]	4.85[a]	4.95[a]	4.85[a]	0.17	<.001
Hemoglobin (g/dl)	10.15	11.90	11.65	12.35	1.40	0.178
MCV (Fl)	67.48[b]	74.32[ab]	72.73[ab]	77.36[a]	3.31	0.019
MCH (pg)	27.61	24.57	23.52	25.48	2.92	0.435
MCHC (g/dl)	40.28[a]	33.06[ab]	32.34[b]	32.94[ab]	2.58	0.016
Serum indices						
Potassium (mmol/L)	4.50[b]	5.05[ab]	5.30[a]	5.50[a]	0.70	0.004
Sodium (mmol/L)	121.00[c]	127.00[b]	138.50[a]	141.50[a]	1.66	<.001
Cholesterol (mmol/L)	1.45	1.35	1.50	2.45	0.46	0.103
Total protein (g/L)	66.00	66.50	66.50	63.15	5.77	0.072
Albumin (g/L)	10.60[c]	12.50[b]	12.95[b]	18.60[a]	1.46	0.045
Creatinine (ųmol/L)	18.35	19.25	25.25	28.40	5.45	0.053
Urea N (ųmol/L)	1.20[b]	1.55[b]	2.70[a]	2.75[a]	0.35	0.339
Phosphate (ųmol/L)	1.35[b]	1.40[b]	1.45[ab]	1.65[a]	0.08	0.005

[abc]Different superscripts in the same row are significantly different ($P < 0.05$) (T0 = 0% *Typha*, T10 = 10% *Typha*, T20 = 20% *Typha*, T30 = 30% *Typha*). *PCV* packed cell volume, *RBC* red blood cell, *MCHC* mean corpuscular hemoglobin concentration, *MCH* mean corpuscular hemoglobin, *MCV* mean corpuscular volume

forage with less 280 g/kg DM is susceptible to clostridial fermentation, which can reduce silage quality. The CP content of Sorghum straw, *Typha domingensis* plant, and gamba hay was lower than the 7% recommended dietary CP level for efficient rumen microbial activities (NRC 1981). The CP (6.83%) of *Typha* silage (TS) in this study was lower than the earlier reports (Anjana and Matai, 1990; De Evan et al. 2019) on the same forage. *Typha* plant is also lower in crude protein when compared with other aquatic plants such as *Limnanthemum cristatum* (24.4%), *Alternanthera philoxeroides* (25.9%), and *Polygonum barbatum* (26.8%) as reported by Anjana and Matai (1990). The NDF of TS in this study was lower than 60% value at which feed intake is depressed (Meissner et al. 1991). Bakshi and Wadhwa (2004) recommended the value of 20–35% NDF for effective ruminal degradation. *Typha*

Table 6 Cost benefit analysis of beef cattle fed *Typha* silage based diets

Parameters	*Typha* silage inclusion level (g/kg)				SEM[1]	*P* value
	T0	T10	T20	T30		
Total cost of feeding ($)	61.62[a]	57.08[b]	53.14[c]	49.60[d]	0.04	<.001
Cost/kg of beef ($)	8.3	8.3	8.3	8.3	-	-
Total weight gain (kg)	12.42	15.33	15.00	15.01	2.02	0.2679
Value of weight gain ($)	103.09	127.24	124.50	124.58	12.56	0.2679
Gross benefit ($)	41.47[c]	70.16[b]	71.36[ab]	74.98[a]	1.47	0.009

SEM[1] pooled standard error of mean (T0 = 0% *Typha*, T10 = 10% *Typha*, T20 = 20% *Typha*, T30 = 30% *Typha*)

[abc]Different superscripts in the same row are significantly different ($P < 0.05$)

silage pH value obtained in this study implicates it to be well preserved silage. Edwards and McDonald (1978) reported that silages with a pH greater than 4.2 are susceptible to putrification by clostridial fermentation. This was not the case in this study. The values of volatile fatty acids obtained in this study are adequate for good fermentation during ensiling process. These results suggest WSC concentration during ensiling *Typha* grass provided adequate substrate for ideal fermentation. Dry matter and crude protein intakes of the feed increased with the level of TS in the diet. This may imply that silage is more palatable than the control diet. The higher inclusion of silage stimulated more intake of the basal diet relative to the control diet. This is consonant with earlier report (Kholif et al. 2015). Low ruminal digestibility of silage may also increase DM intake as opined by M'hamed et al. (2001) and Kholif et al. (2015). The differences observed in the ADF intake of beef cattle may be attributed to the variation in the fiber fractions of TS and sorghum straw. Also, the similarity observed in average weight gain and feed efficiency across the treatments implied that the diets were able to meet up with the nutrients required for proper growth of the animals and that up to 300 g/kg TS can replace sorghum straw in beef cattle diets without adverse effect on growth performance.

The increase observed in concentrations of RBC and MCV among cattle fed TS diets may be attributed to an improvement in erythropoiesis, thereby improving the oxygen-carrying capacity of the blood (Okunade et al. 2016), preventing hypoxia among cattle fed these diets. Lower values of erythrocytic indices in animals have been attributed to the incidence of anemia (Mitruka and Rawnsley, 1977). Since our values however fall within the normal ranges for healthy cattle (Mitruka and Rawnsley, 1977), no health problem was observed during the study. Serum biochemical values are used in diagnosis of diseases (Okunade et al. 2016). The serum electrolytes (K, Na, and P) concentrations followed similar pattern. The values obtained for K were within the established range of 3.5–6.7 mmol/L (Mitruka and Rawnsley, 1977) implying TS consumption did not affect the absorption and availability of the major serum minerals. The trend observed in serum albumin indicated improved synthesis of protein and adequate humoral immunity among cattle fed TS diets (Abonyi et al. 2013). Lower serum urea N level observed among cattle fed T0 and T10 diets implies superior N quality due to reduced deamination of dietary protein since CP intake was similar. Generally, the results of blood parameters implied that feeding TS to beef cattle at 300 g/kg did not affect health status of the animals.

Cost benefit analysis showed that the total cost of feeding reduced in TS-based diets. This implied that replacing sorghum straw with TS reduces cost of feed and about 19.51% could be saved if up to 300 g/kg TS is added to beef cattle diets. The increase observed in the values of gross benefits among cattle fed 300 g/kg TS-based diet in this study is a reflection of lower cost, better quality, and economic superiority of this diet. Olafadehan et al. (2014) reported that unconventional ingredients were more economical when used to substitute conventional ingredients in ruminant diets.

Conclusion

From the results obtained in this study, it can be concluded that up to 300 g/kg TS can be incorporated in the diet of beef cattle to replace sorghum straw with no negative influence on feed intake, blood profile, economics of production, and growth performance of beef cattle.

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Author contribution EF and KR conceived the study and designed research. AR, JS, OJ, AM, MA, MC, and CH conducted experiment. OJ and EF analyzed the data and drafted the manuscript. IE participated in its design. SA corrected and revised the drafted manuscript. All authors read and approved the final manuscript.

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Availability of data and materials All data generated and analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate The experimental procedures followed the animal care of the Committee of the NIAS/ANS/FUGA (001). All authors agreed to submit the manuscript to *Tropical Animal Health and Production*.

Research involving human participants and/or animals The experimental procedures followed the animal care of the Committee of the NIAS/ANS/FUGA (001).

Informed consent All authors agreed to submit the manuscript to *Tropical Animal Health and Production*.

Consent for publication All authors made substantial contributions to the conception or design of the work, improvement of the manuscript.

Competing interests The authors declare no competing interests.

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