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Effect of lemon grass powder on performance, carcass and meat quality characteristics of goats fed cassia seed meal

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Abstract
The study was carried out to determine the effect of lemon grass powder on performance, carcass and meat quality characteristics of goats fed diets comprising different levels of cassia seed meal. Twenty four West African dwarf male goats aged between 8 and 9 months were randomly assigned to four dietary treatments with six goats each. They received basal diet of grass hay supplemented with diets that contained 2% of lemon grass powder with cassia seed meal of 0, 5, 10 and 15% for diets CSM 0% (control group), CSM 5%, CSM 10% and CSM 15% respectively. Results obtained show that crude protein with daily feed intakes, feed conversion ratio, eating rate, chilling with cooking losses, rumen and large intestine were significantly ($P<0.05$) higher in diet CSM 0% than other diets. Diet CSM 10% was higher significantly ($P<0.05$) in crude fibre intake, weight gain, crude protein with fibre digestibility, cooking yield, dressing percentage, fat and water retention with overall acceptability but ruminating rate was better in CSM 15%. Significant difference ($P>0.05$) did not occur in intake with digestibility of ash, percentage weight of kidney, liver, spleen, flavour and appearances. In conclusion, the addition of 2% lemon grass powder to diets containing 5% or 10% cassia seed meal improved performance, carcass and meat quality characteristics of goats indicating that this diet can serve as alternative protein supplement to poor quality forages.

Keywords: cooking yield, feed conversion ratio, herbs, nutrient digestibility, ruminant

Introduction

Goat rearing is considered as an important principal livestock activity in various parts of the world for majorly meat and milk production. They are estimated by Nigeria livestock population that includes about 34.5 million goats, 22.1 million sheep, 16.9 million cattle and 100 million poultry birds [1]. However, goats are multi-functional animals that are relatively easy to keep in adverse and harsh conditions. Their production is pivotal for sustainable human development as they play several diverse roles in the socio-cultural and economic life of their owners. They also make valuable contribution to combat households' malnutrition and poor-resource farmers living under extremely difficult conditions in rural areas, which in turn generate income and end poverty [2]. Despite these attributes, the production of goats in Nigeria still remain low especially among the rural farmers. Nutritional constraints resulting from unavailability of all year round feeds has been the major factor limiting their productivity. The relevance of feeding conventional feeds to augment poor quality forages most especially during the dry season has been questioned from the socio-economic point of view, due to escalating cost of feeds [2]. Utilization of alternative feeds could have be the best option for increasing feeds availability for resource limited farmers. Unfortunately, the effort of using unconventional feeds to improve the levels of goat feeding in the tropics has not yield much desire results due to low nutrient, high fibre with anti-nutritional factors. To mitigate this problem of poor utilization of alternative feed resources, there is need to encourage the use of herb plants as feed additives to optimize the potentials of poor quality feeds for efficient feed utilization and better performance of goats.

Sickle pod (*Cassia tora*) is a common herbaceous annual occurring weed that belongs to the family of *leguminosae*. The seed is classified as a good potential of unconventional plant protein supplement that is gradually gaining importance in addressing the problem of protein shortage in livestock feeds. Sanjay [3] reported that cassia seed meal can be fed or replace steadily up to 10% without adverse effect on the milk yield of cows but 20% level of inclusion in diets is less palatable but with boiling and drying it becomes palatable to ruminants. It is interesting to note that the demand for herb plants has become popular strategy, because of their natural anti-microbial and worldwide trend towards the use of natural additives in livestock feeds. Phytogenic plants are very important target to be investigated due to their healthful price to combat ill-health and replacement supply of natural anti-oxidant. Lemon grass (*Cymbopogon citratus*) is one of such herb plants that are found in Nigeria. It is wild aromatic perennial grass that contains valuable active compounds like citral, steroids, flavonoids and nutrimental citrates [4]. Thus, applying appropriate levels like 2 to 3% lemon grass powder on feeds for livestock could make the broad anti-oxidative, anti-microbial activities and anti-carcinogenic medication agents which could be helpful for maintaining meat quality, extending shelf-life and preventing economic loss [5, 6]. Regardless of these attributes, lemon grass has not received much attention as one of the most favourable alternative to antibiotics for small ruminants especially among the rural farmers in tropics. Thus, the focus of this study was coined to concisely examine the effect of lemon grass powder on performance, carcass and meat quality characteristics of goats fed varying levels of cassia seed meal.

Materials and Methods

Experimental site

The experiment was carried out at the Small Ruminant Unit of the Faculty of Agriculture Teaching and Research Farm, Ambrose Alli University, Ekpoma, Nigeria. The area is located in humid climate zone of south-south Nigeria which lies on latitude $6^0$42'N, longitude $6^0$09'E and altitude 77^0. It receives annual mean rainfall of about 1556 mm, temperature of 32 ^{0}C and relative humidity of 84% in accordance to the report of [7].

Preparation of experimental diets

Lemon grass leaves were harvested from available plants around Ekpoma regardless of the age. They were placed on iron sheet and air dried under a well-ventilated shed to ensure uniform drying until they were crispy when touch for safe storage and prevention of nutrient loss from vitalization. The dried leaves were ground to pass through a 0.15 mm sieve to obtain a product referred to as lemon grass powder. Matured dried pods of *Cassia tora* were also harvested during dry season in Ekpoma, threshed open to obtain the seed grains. The seeds were cleaned to remove impurities and husk mechanically before the raw seeds were boiled with water for 90 minutes in accordance to the procedure described by [8]. Thereafter, the boiled water was drained off from the seed, sundried for 5 days and crushed to form cassia seed meal. Cowpea husk were collected at processing center, dried and crushed into feed. Guinea grass was harvested at the age of 8 and 9 weeks, air dried until about 80 to 85% dry matter to prevent spoilage and retain greenish coloration. It was then stored for several days and latter product was subsequently regarded as grass hay. The grass was hand chopped into a size of about 5 cm for easy feeding by goats. Samples of the lemon grass powder, cassia seed meal, cowpea husk and guinea grass were subjected to proximate composition (Table 2) before being used in diets formulation. Other feed ingredients used for the diets were bought from nearby private farm in Ekpoma.

All experimental goats had access to the basal diet of grass hay. Four compared supplementary diets that were compounded include 2% of lemongrass powder with cassia seed meal at 0%, 5%, 10% and 15% levels of inclusion respectively, to obtain iso-nitrogenous diet (Table 1). However, the basal and supplementary diets were used in a ratio of 60:40 in form of total mixed ration.

Table 1: Gross composition of supplementary diets containing varying levels of cassia seed meals

Parameters	Treatment Diets			
	CSM 0%	CSM 5%	CSM 10%	CSM 15%
Wheat offal	46.00	44.00	42.00	40.00
Brewer dry grain	33.00	32.00	31.00	30.00
Cassia seed meal	-	5.00	10.00	15.00
Cowpea husk	15.50	13.50	11.50	9.50
Lemon grass powder	2.00	2.00	2.00	2.00
Bone meal	2.50	2.50	2.50	2.50
Salt	1.00	1.00	1.00	1.00
Total	100	100	100	100
Calculated composition (%DM)				
Crude protein	16.97	16.89	16.73	16.53

Animal management and experimental design

Twenty-four West African dwarf male goats of about 8 to 9 months of age were sourced within Ekpoma livestock market for the study. On arrival, they were quarantined for a period of 14 days during which they were dewormed with Ivomec against internal parasites and treated against ecto-parasites using diazintol solution according to the manufacturer's instructions. Subsequently, they were injected with oxytetracycline antibiotic (LA) through intramuscular at the dosage of 1ml/10kg live weight of the animals to enhance their resistance to infections. After the quarantine measured, goats were balanced for weight with initial mean body weight of 8 ± 0.27 kg and labeled with wooden tags for easy identification. Thereafter, they were housed individually in dwarf pens measured about 1.8m^2 with provision for feeding and watering troughs. Wood shaving was spread on the floor as litter, which was changed once every week. The feeding trial was a completely randomized design of one control and three test diets. Six goats were randomly assigned to each treatment with three replicates of two goats per replicate. Goats were fed at 2.5%(DM) of their body weight twice daily at about 8:00am and 4:00pm inform of complete mixed ration to enhance voluntary consumption according to the recommendation of [9]. Goats had free access to water throughout the study and the trial was conducted for 84 days exclusive the 14 days quarantine period.

Data collection procedures

Feed intake, growth and feeding behaviour: The average daily feed consumption was estimated by the difference between the amount of feed offered and leftover, while nutrient intake was determined as feed intake multiply by the nutrient in feeds. Body weight of each goat was measured and recorded at the onset of the study and subsequently once a week with measuretech® hanging scale prior to morning feeding to determine change in body weight. Data derived from daily feed intake and weight gain were computed to estimate feed conversion ratio.

Eating and ruminating time were continuously monitored by two people during the periods of 24 hours for every two days in a week throughout the feeding trial. The time spent in eating and ruminating was recorded. The intake and ruminating rates were calculated as reported in past study of [10]

$$\text{Intake rate (g/min)} = \frac{\text{Total DM intake (g)}}{\text{Eating time (min)}}$$

$$\text{Ruminating rate (g/min)} = \frac{\text{Total DM intake (g)}}{\text{Ruminating time (min)}}$$

Nutrient digestibility: Growth study was preceded by a 14 day metabolic trial to determine apparent nutrient digestibility of the diets. Three goats per treatment were randomly selected and housed separately in individual metabolic cages designed for feeding, watering with separate collection of faeces and urine. The goats were allowed 7 days to adjust to the environment before a 7-day collection of feeds, leftover and faecal samples. At the end of collection period for each goat, they were separately bulked; thoroughly mixed and about 10% of the sub-samples were pooled and stored at -20 ^{0}C in airtight container until they were required for analysis. Thus, apparent nutrient digestibilities of the diets were calculated by the standard procedures outlined for the direct estimation of animal digestibility [11].

Carcass and meat quality: After the 14 days of metabolic trial, three goats per treatment were randomly selected and starved for 16 hours. They were weighed to obtain slaughter weight (SW) and stunned before slaughtered [12]. After bleeding, the skin, head and limbs were removed before carcass were washed and eviscerated. The weights of carcass parts were also recorded. Hot carcass weight (HCW) was determined after the removal of the head, skin, intestinal tract and internal organs [13]. Dressing percentage was then calculated as the proportion of hot carcass weight to slaughter weight. The cold carcass weight (CCW) was obtained when the carcass was conducted to the cold chamber (average 4^0C) after 24 hours cooling while chilling losses (CL) was quantified using the formula below as reported by [14].

CL (%) = (HCW – CCW) x 100
HCW
1

Thereafter, the carcass were then divided into primal cuts and chop of meat before samples were removed from the anterior side of the loin, weighed and then cooked into a plastic bag in a water bath at 75 ^{0}C until an internal temperature of 71 ^{0}C was achieved. Samples were removed from the bags, dried with filter paper to remove cooking drip and reweighed [15]. Chop meat samples of cooking loss and cooking yield were then calculated using these formulas;

$$\text{Cooking loss (\%)} = \frac{\text{Initial weight} - \text{final weight x 100}}{\text{Initial weight} \qquad 1}$$

Cooking yield (%) = 100 – cooking loss

Moisture and fat retention in the meat were also calculated as reported by [5].

$$\text{Moisture retention \%} = \frac{\text{Cooking yield x \% moisture in cooked meat}}{\text{\% moisture in raw meat}}$$

$$\text{Fat retention \%} = \frac{\text{Cooking yield x \% fat in cooked meat}}{\text{\% fat in raw meat}}$$

Moreover, sampled for sensory evaluation were cut into sub-samples, transferred into a pre-warmed glass-beaker and covered. In order to assess the meat quality, panelists were randomly assigned to the four treatment groups. The meat samples were coded and served in randomized sequence. The panelists were made to rate each of the replicates of the meat sample per meat quality index per treatment. They rated the samples on a 9 point hedonic scale for flavour, tenderness, texture, juiciness, appearances and overall acceptability. They were also semi-trained before starting the test and were supplied with cracker biscuits and water in between the samples [16].

Chemical analysis

The proximate and chemical analysis of feeds, experimental diets and faecal samples were done according to [17]. Dry matter content was determined by drying the samples at 105^0C overnight, ether extract was determined when a weighed sample was washed for several hours with lipid solvent ether, the weight difference between the initial and after extraction was the ether extract. Ash was derived by combusting the sample at 550 ^{0}C for 5 hours. Nitrogen (N) was extracted with Kjeldhal method before the crude protein was estimated by N x 6.25. Crude protein was determined after extracted lipids from the samples which followed by the removal of acid and alkali soluble materials by boiling in dilute sulphuric acid and sodium hydroxide to obtain insoluble material called crude fibre. Nitrogen free extract was determined by subtracting the sum values obtained in all fractions measured from 100%. The content of acid and neutral detergent fibre were analyzed using the method reported by [18].

Statistical analysis

Data generated were subjected to one way analysis of variance (ANOVA) using the general linear model procedure of SAS version 9.3 [19]. Where significant differences occurred among treatment means, they were separated by Duncan multiple range test. The linear model below explained the statistical tools used to analyze the data;

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

Where;
Y_{ij} = the observed j^{th} variable in the i^{th} treatment diet (fixed factor)
μ = overall means of the observed variable
A_i = effect due to i^{th} treatment diets (i = CSM 0%, CSM 5%, CSM 10% and CSM 15%)
e_{ij} = random residual error

Comparisons with $P < 0.05$ and $P < 0.01$ were considered significant and all statements of statistical differences were based on these levels

Results

Nutrient contents of feed ingredients

The result in Table 2 shows that dry matter and crude fiber content of grass hay recorded the highest among feed ingredients but lowest in ash. Values of crude protein in cassia seed meal, lemon grass powder and cowpea husk were similar and relatively higher than value registered in grass hay. Lemon grass had the highest in ether extract but lowest in nitrogen free extract with remarkable difference from other feeds.

The anti-nutrient content of cassia seed and lemon grass are showed in figure I. Cassia seed had relatively lower in concentration of anti-nutrients than lemon grass.

Table 2: Proximate composition (%DM) of processed feed ingredients

Parameters	Cassia seed meal	Lemon grass powder	Cowpea husk	Grass hay
Dry matter	89.47	94.05	90.35	97.83
Crude protein	10.73	10.37	11.21	4.01
Crude fibre	11.25	16.72	26.12	37.23
Ether Extract	3.01	15.94	1.01	2.45
Ash	5.86	9.38	9.03	5.18
Nitrogen free extract	58.63	41.64	47.36	48.96

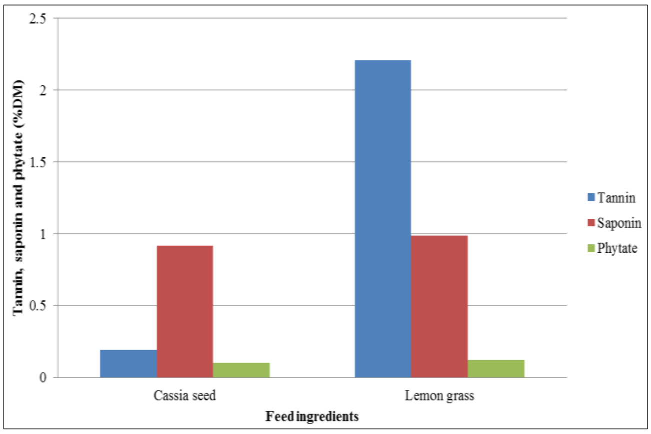

Fig 1: anti-nutrient concentration of cassia seed meal and lemongrass powder.

Chemical composition of the experimental diets

Table 3 indicates the chemical composition of the experimental diets. Dry matter and nitrogen free extract were lower in diet without cassia seed meal as compared with test diets. Crude protein content obtained was slight lower than the calculated value but generally similar in values among diets, though the control group was relatively higher in numerical value. Crude fibre and its fractions registered higher values in control diet (CSM 0%) than the values recorded in test diets (CSM 5%, CSM 10% and CSM 15%). Ether extract and ash contents obtained in the study were similar across the treatment diets.

Table 3: Chemical composition (%DM) of the experimental diets

Parameters	CSM 0%	CSM 5%	CSM 10%	CSM 15%
Dry matter	90.74	93.62	91.97	92.18
Crude protein	16.00	15.96	15.73	15.52
Crude fibre	12.02	11.93	11.76	11.56
Ether Extract	4.88	4.85	4.82	4.80
Ash	5.27	5.42	5.40	5.30
Nitrogen free extract	51.44	55.46	52.36	55.00
Acid detergent fibre	14.13	12.92	12.64	11.99
Neutral detergent fibre	26.01	24.01	23.98	23.84

Intake and live weight gain

As presented in Table 4, crude fibre intake that varied significantly ($P<0.05$) across diets had highest values in goats on CMS 5% and CMS 10% and lowest on CMS 0% and CSM 15%. However, crude protein and ether extract intakes were significantly ($P<0.05$) better in control diet while ash was found not to be significantly difference (p >0.05) among diets.

Final body weight had significant difference ($P<0.05$) with goats on test diets recorded higher values than that on control diet. Total and daily weight gains were higher significantly in CSM 10% as compared with control and other test diets. Overall daily feed intake was observed to be significantly lowest ($P<0.01$) in test diets (CSM 5%, CSM 10% and CSM 15%) and highest in control diet (CSM 0%). Goats on CSM 5% and CSM 10% had lower and better feed conversion ratio than those on CSM 0% and CSM 15%.

Table 4: Effect of lemon grass powder on intake and growth of goats fed different levels of cassia seed meal

Parameters	Treatment Diets				SEM	LS
	CSM 0%	CSM 5%	CSM 10%	CSM 15%		
Crude protein intake (%)	72.54[a]	69.04[b]	68.73[b]	66.99[c]	0.87	*
Crude fibre intake (%)	70.06[b]	73.16[b]	75.02[a]	71.27[b]	0.77	*
Ether extract intake (%)	78.72[a]	61.98[b]	61.43[b]	62.05[b]	0.82	*
Ash intake (%)	70.25	71.11	71.05	70.79	0.69	NS
Live weight change						
Initial body weight (kg)	8.54	8.39	7.99	8.14	0.16	NS
Final body weight (kg)	10.98[b]	11.62[a]	11.78[a]	11.13[a]	0.34	*
Total body weight gain (kg)	2.44[c]	3.23[b]	3.79[a]	2.99[b]	0.06	*
Daily weight gain (g)	34.86[c]	46.14[b]	54.14[a]	42.71[b]	0.98	*
Daily feed intake (g)	306.79[a]	274.28[b]	269.86[c]	257.95[c]	1.38	**
Feed conversion ratio	8.80[a]	5.95[b]	4.98[c]	6.09[b]	0.06	*

[a,b,c] means with different lowercase letters in the same row are significantly different ($P<0.05$), SEM = standard error of mean, * = $P<0.05$, ** = $P<0.01$, NS = not significant, LS = level of significant

Feeding behaviour and nutrient digestibility

As illustrated in Table 5, are results for chewing activities and nutrient digestibility. There was significant difference ($P<0.01$) in eating rate (E) of goats among diets. It was obviously observed that the time spent by goats on eating control diet CSM 0% was higher than the hours and minutes spent on test diets (CSM 5%, CSM 10% and CSM 15%). Ruminating rate (R) as well was varied significantly ($P<0.05$) according to diets, goats on diets with cassia seed meal had longer time in ruminating than those on control diet. However, E + R followed the same trend as noticed in eating rate, while ratio of E and R was not significantly (p > 0.05) influenced by diets.

Apparent digestibility of nutrients were significantly ($P<0.05$) higher in diets with cassia seed meal than the control diet with exception of ether extract and ash. Notwithstanding, ether extract that was found significant ($P<0.05$) according to diets was better digested in goats on test diets than the control diet. Ash digestibility was not significantly (p > 0.05) affected by treatment diets.

Table 5: Feeding behavior and nutrient digestibility on goats fed experimental diets

Parameters	Treatment Diets				SEM	LS
	CSM 0%	CSM 5%	CSM 10%	CSM 15%		
Eating rate min/24h	391.62^{a}	368.02^{b}	342.46^{b}	324.67^{c}	2.82	**
Ruminating rate min/24h	197.03^{b}	201.74^{a}	213.09^{a}	220.45^{a}	1.97	*
E + R min/24h	588.65^{a}	569.76^{b}	556.15^{b}	545.12^{c}	1.76	**
E and R ratio	1.99	1.82	1.60	1.47	0.05	NS
Digestibility (%)						
Dry matter	72.24^{c}	78.22^{b}	81.03^{a}	76.46^{bc}	0.67	*
Crude protein	61.84^{c}	70.83^{a}	73.37^{a}	68.95^{b}	0.79	*
Crude fibre	63.02^{c}	68.92^{b}	70.96^{a}	66.87^{b}	0.48	*
Ether extract	63.71^{a}	58.89^{b}	57.78^{b}	57.19^{b}	0.53	*
Ash	62.71	62.52	61.44	61.63	0.05	NS
Acid detergent fibre	39.34^{c}	42.65^{ab}	44.35^{a}	40.14^{b}	0.98	*
Neutral detergent fibre	57.48^{c}	63.91^{a}	65.08^{a}	61.87^{b}	0.87	*

^{a,b,c} means with different lowercase letters in the same row are significantly different (*P*<0.05), SEM = standard error of mean, * = *P*<0.05, ** = *P*<0.01, NS = not significant, LS = level of significant, E = eating rate, R = ruminating rate.

Carcass characteristics

Slaughter with hot carcass weights, dressing percentage and thorax of goats on diets supplemented with cassia seed meal were significantly higher (*P*<0.05) than those on control diet (Table 6). Similarly, neck, heart and cold carcass weight followed the same trend as slaughter weight but highly significant (*P*<0.01) among treatments. Chilling loss was also difference across diets with higher significant (*P*<0.05) value being recorded in goats on CSM 0% than CSM 5%, CSM 10% and CSM 15%. However, difference (P > 0.05) did not occur in rack, lumber, kidneys and liver.

Table 6: Effect of lemon grass powder on carcass traits of goats fed cassia seed meal

Carcass components	Treatment Diets				SEM	LS
	CSM 0%	CSM 5%	CSM 10%	CSM 15%		
Slaughter weight (kg)	10.99^{b}	11.74^{a}	11.89^{a}	11.02^{ab}	0.06	*
Hot carcass weight (kg)	4.99^{c}	5.90^{ab}	6.06^{a}	5.14^{b}	0.13	*
Cold carcass weight (kg)	4.01^{b}	5.02^{a}	5.39^{a}	4.20^{b}	0.08	**
Dressing (%)	45.41^{b}	50.26^{a}	50.97^{a}	47.73^{ab}	1.34	*
Chilling loss (%)	19.64^{a}	14.92^{b}	11.06^{b}	17.29^{ab}	0.94	**
Neck (kg)	0.41^{b}	0.78^{a}	0.82^{a}	0.69^{ab}	0.87	**
Heart (kg)	0.09^{b}	0.14^{a}	0.14^{a}	0.13^{a}	0.74	**
Thorax	1.02^{b}	1.47^{a}	1.55^{a}	1.34^{a}	0.14	*
Rack (kg)	0.21	0.21	0.24	0.22	0.07	NS
Lumber (kg)	0.48	0.48	0.49	0.49	0.05	NS
Kidney (kg)	0.30	0.32	0.31	0.32	0.06	NS
Liver (kg)	0.05	0.04	0.04	0.05	0.09	NS

^{a,b,c} means with different lowercase letters in the same row are significantly different (*P*<0.05), SEM = standard error of mean, * = *P*<0.05, ** = *P*<0.01, NS = not significant, LS = level of significant

Relative organ properties

Table 7 shows relative organ properties of goats fed varying levels of cassia seed meal supplemented with lemon grass powder. Skin, rumen and large intestine of goats were significantly decreased (*P*<0.05) in values as levels of cassia seed meal inclusion increased in the diets. The proportional yield of lung, head, testis, gallbladder, trotters, small intestine and blood were significantly higher (*P*<0.05) in test diets than the control diet. Spleen and trachea percentage did not show any level of disparity (P > 0.05) among diets in relative organ traits of goats.

Table 7: Relative organ properties of goats fed varying levels of cassia seed meal supplemented with lemon grass powder.

Parameters (%)	Treatment Diets				SEM	LS
	CSM 0%	CSM 5%	CSM 10%	CSM 15%		
Skin	9.14^{a}	8.76^{b}	8.85^{b}	8.99^{ab}	0.62	*
Lung	0.86^{b}	0.91^{a}	0.93^{a}	0.89^{a}	0.07	*
Head	4.26^{b}	4.64^{a}	4.68^{a}	4.60^{a}	0.03	*
Spleen	0.13	0.14	0.15	0.14	0.05	NS
Testis	0.68^{b}	0.96^{a}	0.99^{a}	0.93^{a}	0.10	*
Gallbladder	0.21^{c}	0.36^{b}	0.42^{a}	0.24^{c}	0.09	*
Trachea	0.69	0.71	0.73	0.70	0.03	NS
Trotters	2.82^{b}	3.49^{a}	3.64^{a}	3.37^{a}	0.26	*
Rumen	3.98^{a}	3.62^{b}	3.59^{b}	3.57^{b}	0.15	*
Small intestine	1.02^{b}	1.77^{a}	1.97^{a}	1.58^{a}	0.14	*
Large intestine	1.99^{a}	1.63^{b}	1.60^{b}	1.69^{b}	0.06	*
Blood	2.98^{b}	3.05^{a}	3.09^{a}	3.01^{a}	0.34	*

^{a,b,c} means with different lowercase letters in the same row are significantly different (*P*<0.05), SEM = standard error of mean, * = *P*<0.05, ** = *P*<0.01, NS = not significant, LS = level of significant

Cooking properties and sensory evaluation

As shown in Table 8, cooking yield with content of moisture and fat were highly significant (*P*<0.01) in cooking goats' meat on diets with cassia seed meal than the control diet. However, yield of cooking loss was higher in goats on control diet as compared with test diets. The result further indicated difference (*P*<0.05) in tenderness, juiciness and overall acceptability with higher values more visible in goats on test diets. Difference (P > 0.05) was not observed among diets for parameters like flavour, appearance and texture.

Table 8: Cooking properties and sensory evaluation of goats fed experimental diets

Carcass components	Treatment Diets				SEM	LS
	CSM 0%	CSM 5%	CSM 10%	CSM 15%		
Cooking yield (%)	57.38^{c}	63.32^{a}	64.93^{a}	60.72^{b}	1.07	**
Moisture retention (%)	32.81^{c}	39.98^{b}	41.23^{a}	37.66^{b}	0.56	**
Fat retention (%)	54.64^{c}	60.75^{a}	62.87^{a}	58.59^{b}	0.98	**
Cooking loss (%)	42.62^{a}	37.68^{b}	35.07^{c}	39.28^{b}	0.87	*
Flavour	5.68	5.97	5.94	5.96	0.15	NS
Tenderness	6.27^{b}	6.91^{ab}	7.28^{a}	6.49^{b}	0.02	*
Juiciness	6.76^{b}	7.08^{a}	7.12^{a}	7.01^{ab}	0.74	*
Texture	5.81	5.94	5.93	5.82	0.04	NS
Appearance	6.69	6.68	6.72	6.65	0.09	NS
Overall acceptability	5.96^{b}	6.79^{a}	6.80^{a}	6.05^{ab}	0.81	*

^{a,b,c} means with different lowercase letters in the same row are significantly different (*P*<0.05), SEM = standard error of mean, * = *P*<0.05, ** = *P*<0.01, NS = not significant, LS = level of significant

Discussion

Nutrient composition of feeds and experimental diets

Dry matter content of feed ingredients and diets were generally high indicating better storage period of nutrients without spoilage. Grass hay had crude protein content that was below the minimum level of 7% requirement for microbial function in the rumen [20]. Thus, cassia seed meal that is easily accessible and affordable protein alternative source was supplemented to augment the available feeds for goats reared by rural farmers. Hence, diets crude protein values were above the critical level of 8.00% requirement for minimum performance of goats as reported by [21]. Variation observed in nutrient of diets could trace to different in levels of feed ingredients used in the study. However, the proximate and anti-nutrient contents of cassia seed meal and lemon grass obtained were lower than values reported by [22] and [23] respectively, due to differences in processing methods. The anit-nutrient content of cassia seed and lemon grass (figure 1) were considered safe and lower with regards to critical value of 4% concentration reported by [24].

Intake and live weight change

The higher intake of crude fibre in goats on diets with cassia seed meal supplement, suggests that fibrous feeds could be a potential source of fermentable carbohydrates which according to [25] are needed in the rumen to provide energy for growth of microbial cell to enhance degradation of fibrous feed materials. However, values of crude protein and ether extract intakes were higher in diet with no cassia seed meal inclusion, implying that the diet could supply adequate protein and oil to goats than test diets. Variations in feed intake have been noted by [26] to be attributed to difference in body weight, type or palatability of the diet and length of time spent on the diet. The reason for the low intake of feed observed in goats on diets with cassia seed meal could probably due to the less palatability which caused the goats to take longer time to adapt to the diets. This shows that longer time is required for rumen flora to become adapt to metabolizing strange feed material librated in the rumen [10]. However, the higher positive weight gain recorded in goats on cassia seed inclusion diets could be attributed to better proportion of energy to protein ratio made available in the diets by bioactive compounds in lemon grass. This might influence the adequate balance of nutrient at site of metabolism which inferred with the optimum growth performance observed in the goats. According to Award [5] growth rate can be influenced by a combination of factors that includes using natural additives in animal feeding, age and physiological state of the animal. Similarly, the measure of feed intake per unit weight gain was lower in test diets. This is an indication that the efficiency at which goats converted the test diets for body weight gain was better. Hence, the negative correlation between weight gain and feed conversion ratio obtained in the study could be an evidence for further attest the superiority of lemon grass in terms of nutrient availability and utilization by goats on test diets.

Chewing behaviour and digestibility

The trends observed on eating habits that reflected clearly on time spent in eating and ruminating rates could be attributed to the physical nature and degree of acceptability of the diets. Rafiee-Yarandi *et al.* [27] reported that physical characteristics and palatability of feeds are major factors that affect eating activity in ruminants. However, the longer ruminating time noticed in goats on test diets was likely related to additional time needed in chewing feeds more efficiently for particle size reduction, nutrient availability and salivary secretion. This confirms the supposition of [27] who observed that increase in particles of feeds that remain in the rumen stimulate ruminating rate for better performance, making rumination to be more important than eating activity in ruminants.

Apparent digestibility of nutrients with exception of ash was influenced by dietary supplementation of lemon grass and cassia seed meal. The progressive increased of cassia seed meal up to 10% inclusion levels in diets resulted in higher digestibility of most nutrients than 15% level of inclusion (Table 5). The interaction between the anti-microbial activity in lemon grass and nutrients in cassia seed meal could probably stimulated the secretion of endogenous digestive enzymes to favour the digestibility of feeds in goats. However, the slight decreased in digestibility of nutrients in goats at 15% cassia seed meal supplementation confirmed the report of [3] who noted a declined trend in digestibility of nutrients and milk yields of cows with increasing dietary inclusion of cassia seed meal from 15% to 20% as replacement for conventional protein feed sources. It is interesting to know that ether extract digestibility decreased with supplementation of lemon grass and increasing levels in cassia seed meal inclusion in the diets. This gradual reduction might be as a result of phytochemical components of lemon grass that caused inhibitory effect on degrading microbes in the rumen that were responsible for digestion cassia seed oil. This finding was in consistent with the report of [28] who observed that rumen microbes seem to be sensitive to phytogenic compounds at a particular level to reduce digestibility of oil in host animals

Carcass and relative organ properties

Slaughter weight and dressing percentage are undoubtedly important tools in carcass evaluation, perhaps they influenced by plane of nutrition, age and management system. The likely mechanism explaining this higher dressing percentage obtained might be related to the availability of valuable nutrient in the test diets over control group. This reflection was also noticeable in the higher positive turned out weights of neck, heart and thorax, hot with cold carcass of goats. The average dressing percentage obtained in this study was higher than mean value of 34.53% reported by [13] for Arsi-bale goats. However, higher chilling loss in carcass of goats on control diet could be as a result of difference in oxidative process that cause degradation of lipid and protein within limiting time period in carcass [5]. Similar weights of rack, lumbar, kidney and liver observed could explained how safety were the test feeds.

Percentage pertaining skin, rumen and large intestine in relative organ of goats were increased on control diet. This could be connected to their active body physiological activity which corresponded to their relative intake of feeds (Table 4). The close values of spleen and trachea might be linked to the age of goats that were similar. Elias *et al.* [12] reported that spleen in animal maintain its integrity due to priority of age rather than dependently on feeding. Other observed parameters (Table 7) in relative organs that were higher in test diets, further testify how better the cassia seed was utilized for heavier weight gain. This fact was in accordance with the view of [12] who reported that better feed utilization result in greater weight with faster acceleration rate of some organs in ruminants.

Cooking properties and sensory evaluation

The addition of lemon grass and up to 10% of cassia seed meal in diets had higher positive influenced on cooking yield which promoted percentage of water and fat retention in Goats meat. The anti-oxidative that improve lipid stability of meat quality could probably responsible for this result. This reason could also explain the noticeable trends observed in tenderness, juiciness and overall acceptability in meat of the goats (Table 8). This agrees with the report of [29] who stated that keeping fat and protein within matrix of meat products during cooking and storage ensure sensory quality and acceptability.

Cooking loss which is the reduction in weight of meat during cooking process was found to be higher in control diet. The faster breakdown of the myofibrils and connective tissue of the meat during cooking might be the possible reasons that promoted the percentage of cooking loss. Nevertheless, average percentage of cooking loss was within the normal range for goat muscle as noted by [13]. The likely reason for similar quality of flavour, appearance and texture irrespective of the diets, could be traced to the phytochemical components in lemon grass that enhanced the quality of the meat. This corroborates the existing literature that herb plants can provide phytogenic compounds that improve meat flavour and appearance [5].

Conclusion

The results of this study show that the addition of lemon grass powder to diets containing different levels of cassia seed meal had considerably enhanced performance, carcass and meat quality characteristics of goats. In conclusion, the addition of 2% lemon grass powder with 5% or 10% cassia seed meal to diets (CSM 5% and CSM 10%) had higher impact on performance, carcass traits and meat quality than control diet (CSM 0%) and 15% cassia seed meal inclusion levels (CSM 15%) in the diets.

Consequently, the use of lemon grass powder in diets containing different proportion of cassia seed meal as supplement to grass hay can be an option for small holder farming condition most especially during the dry season to improve their ruminant livestock particularly goats, where conventional protein sources are scarce and unaffordable in the tropics. Notwithstanding, more research work are needed to be done in area of actual maximum level of cassia seed meal inclusion in the diets of goats.

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