



Nutritional assessment of ensiled fresh maize stover with different proportions of cassava foliage for sustainable ruminant production

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Abstract

Assessment of nutritional qualities for ensiled fresh maize stover with different proportion of cassava foliage for sustainable ruminant production was studied. Fresh maize stover (FMT) and fresh cassava foliage (FCF) were collected, wilted for 3 – 4 days, chopped and ensiled in different proportions to make six (6) experimental treatments (T1= 100% FMT; T2= 90% FMT + 10% FCF; T3= 80% FMT + 20% FCF; T4=70% FMT + 30% FCF; T5= 60% FMT + 40% FCF; T6= 50% FMT + 50% FCF). Twenty five (25) liters containers were used as silos with four replicates in completely randomized design (CRD) and ensiled for 30 days. Physical parameters, proximate composition, fibre fractions, mineral contents, anti-nutritional factors and post in-vitro characteristics were monitored. The results showed that pleasant aroma, smooth texture and no moldiness were observed across the experimental treatments. There were significant ($P<0.05$) differences in the crude protein (CP), crude fibre (CF), ash, non fibre carbohydrate (NFC), neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and cellulose. Similar ($P>0.05$) contents of hemicellulose were recorded across the experimental treatments. The anti-nutritional factors varied significantly ($P<0.05$) from 0.42 – 0.46 %, 0.35 – 0.39 %, 0.47 – 0.50 %, 0.02 – 0.05%, 2.63 – 3.09 and 12.90 – 15.23, for phytate, oxalate, saponin, tannin, trypsin inhibitor and hydrocyanide, respectively. Significant ($P<0.05$) differences in the mineral contents and post in vitro characteristics were also observed across the experimental treatments. Conclusively, T4 (30%), T5 (40%) and T6 (50%) inclusion levels of FCF give better results. It's therefore recommended that FCF up to 50% inclusion levels can be ensiled with maize stover for sustainable ruminant production.

Key words: Cassava-foliage; maize-stover; nutritional; ruminant; silage;

Introduction

Ruminants play a crucial role in the economic and social-cultural advancement of Nigerians. Natural pasture has been the major source of feed for ruminants but it is characterized by poor nutrients quality and quantity especially during the dry season. Crop wastes or residues have been used in different forms to curb the challenges of dry season feeding for ruminant production. Maize stover is the leftover of maize plants after the husk has been removed. Most maize farmers normally harvest the husk as soon as it is matured and the remnants is referred to as maize stover. They are allowed to dry off or attacked by insects. Lamidi and Joseph (2020) reported that maize stover is made of leaf and stem of harvested maize

which can be used for feeding ruminants. Cassava foliage is the leaves of the cassava plant after the tubers have been harvested. It has been used in different forms for livestock production especially ruminants, though highly nutritious, it has some ant-nutritional factors such as cyanide which can hinder its utilization.

Silage is defined as any plant material that has undergone fermentation or “pickling” in a silo, while silo is any storage structure in which green, moist forage is preserved (Amuda *et al.*, 2019). The primary goal of making silage is to maximize the preservation of original nutrients in the forage crop for feeding of livestock at a later date in livestock feeding programs.

Silage production has been a means in which value can be added to the forage (Lamidi and Ingweye, 2020). Silage production is also a sustainable strategy for ensuring feeds availability for ruminant animal production throughout the year. It is imperative to evaluate the nutritional qualities of ensiled fresh maize stover with different proportion of cassava foliage for sustainable ruminant production.

Materials and method

Experimental site

The study was carried out at the Forage Science Laboratory, Department of Animal science, Faculty of Agriculture, University of Port Harcourt, Rivers State. Port Harcourt is a coastal city located in the Niger Delta region of Nigeria within latitudes 6° 58' – 7° 60'E and longitudes 4° 40' – 4°55'N. The monthly rainfall in Port Harcourt follows a sequence of increase from March to October before decreasing in the dry season months of November to February (Uko and Tamunobereton, 2013; Lamidi and Ogunkunle, 2016).

Experimental site and collection of experimental materials: The experiment was conducted at the Forage Science Laboratory, Department of Animal Science, University of Port Harcourt, Port Harcourt, Rivers State. Cassava leaf and maize stover were harvested from the Faculty of Agriculture Teaching and Research Farm after fresh maize has been harvested, the leftover of the maize plant (maize stover) were cut 15cm above the soil. Cassava leaf/foliage was also gathered from harvested cassava plants. Both the fresh crop wastes (maize stover and cassava foliage) were allowed to wilt for 2-3 days.

The wilted maize stover and cassava foliage were chopped to 3 - 5 cm with a forage chopper machine separately and later weighed on percentage bases as follows:

T1 = 100% of Maize stover; T2 = 90% of Maize stover + 10% cassava foliage

T3 = 80% of Maize stover + 20% cassava foliage; T4 = 70% of Maize stover + 30%

cassava foliage; T5 = 60% of Maize stover + 40% cassava foliage; T6 = 50% of Maize stover + 50% cassava foliage

The experimental materials were ensiled in 25 liters containers. The silos were tightly tied and covered to avoid air penetration. Each treatment had four replicates and the ensiled materials were kept at room temperature of 28 and 32 °C for 30 days.

Data collection

Physical characteristics as well as temperature (°C) and pH of the silage were determined immediately the silos were opened. Physical characteristics of ensiled fresh maize stover and cassava foliage were carried out according to the procedures of Lamidi and Akhigbe (2018), while pH and temperature were determined using Digital pH Meter. Sub-samples of the silage were oven-dried, ground with a Thomas Willey Laboratory Mill-Model 4 to pass through 1 mm sieve.

Chemical analysis

Proximate composition

The dry matter, crude protein, ether extract and Ash contents of the milled silage sample were determined according to A.O.A.C. (2000). Non-fibre carbohydrate was calculated as NFC = 100 - (CP + Ash + EE + NDF).

Fibre fraction analysis

Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) of the milled grass sample were determined with the procedure of Van Soest *et al.* (1991). Cellulose content was taken as the difference between ADF and ADL while hemicellulose content was also calculated as the difference between NDF and ADF. Mineral composition of the samples was carried out using the

Atomic Absorption Spectrophotometer of AOAC (2005).

Anti-nutritional factors

Tannin and saponin contents were determined according to the methods described by Lamidi and Ogunkunle, (2015). Oxalate was according to Munro (2000) while phytate was determined as described by Prokopet and Unlenbruck (2002).

In vitro digestibility trial

The *in vitro* trial was carried out at the laboratory of Department of Animal Science, University of Benin, Benin City, Edo State, Nigeria. The modified *in vitro* fermentation procedure of Navarro-Villa *et al.* (2011) was adopted as described by Bamikole *at al.* (2019). The phosphate – bicarbonate buffer (Mould *et al.*, 2005) used (g/L) were: 1.98 Na₂HPO₄.12H₂O, 1.302 KH₂PO₄, 0.105 MgCl₂.6H₂O, 1.407 NH₄ HCO₃, 5.418 NaOH. Rumen fluid was obtained from three fistulated goats before morning feeding into a thermos flask and taken to the laboratory where it was strained through four layer of Cheesecloth under continuous flushing with CO₂. Inoculum for incubation was prepared using ratio of rumen fluid to buffer of 1:2. 190 mg of substrate (mixture of equal proportion ground maize, Guinea grass and *Centrosema molle*) was weighed with 10 mg of the test material (experimental treatments) into nylon bags, sealed and incubated using 30ml of inoculum in 100 ml graduated syringes at 30°C for 24 hours. Syringes containing only the substrate (i.e. without the experimental treatments) and those containing only the inoculum (i.e. without sample) represented the control and blank, respectively. Gas production (i.e. accumulated gas in the head space of each fermentation syringe) was read 3 hourly for 24 hours to know the volume of gas produced. At the end of incubation, 4ml of 10M NaOH was introduced into the headspace of the syringes for methane determination. The

bags with the residue were removed from the syringes, rinsed thoroughly with water and dried at 100°C for 24 hours, and then to constant weight to determine *in vitro* dry matter disappearance (IDMD).

Calculation for post incubation parameters

Organic matter digestibility (OMD) was estimated as: $OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 \text{ ashes}$ (Menke and Steingass, 1988).

Short-chain fatty acids (SCFA) were estimated as: $SCFA = 0.0239 GV - 0.0601$ (Getachew *et al.*, 1999).

Metabolizable energy (ME) was calculated as: $ME = 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF$ (Menke and Steingass, 1988).

Fermentation Efficiency (FE) was calculated as: $Fermentation\ Efficiency\ (FE) = \frac{Dry\ matter\ Digestibility\ (g/kg)}{Total\ Gas\ Volume\ (mL/g)}$.

Data analysis

The experimental design was a completely randomized design (CRD), in which the experimental treatments were the only source of variation.

The statistical model is as follows: $X_{ij} = \mu + T_i + \sum_{ij}$

Where X_{ij} = value of observation; μ = population mean; T_i = treatment effect; \sum_{ij} = error term

All data obtained were subjected to analysis of variance (ANOVA). Means were separated using Least Significant Difference (LSD) of the SAS (2000) package.

Results

Table 1 shows the physical characteristics, temperature and pH of ensiled fresh maize stover

with different proportions of cassava foliage. Pleasant, smooth and none moldiness were recorded for aroma, texture and moldiness across the experimental treatments. The colour was yellowish-green for T1 and T2 and,

brownish-green for T3, T4, T5 and T6. The temperature and pH ranged from 32 – 35°C and 4.6 – 4.9, respectively.

Table 1: Physical characteristics, temperature and pH of ensiled fresh maize stover with different proportions of cassava foliage

Treatments					Silage qualities		
	Colour	Aroma	Texture	Wetness	Moldiness	Tem. (°C)	pH
T1	Yellowish-green	Pleasant	Smooth	Dry	None	33	4.9
T2	Yellowish-green	Pleasant	Smooth	Moist	None	34	4.6
T3	Brownish-green	Pleasant	Smooth	Moist	None	35	4.7
T4	Brownish-green	Pleasant	Smooth	Moist	None	32	4.6
T5	Brownish-green	Pleasant	Smooth	Moist	None	34	4.6
T6	Yellowish-green	Pleasant	Smooth	Moist	None	33	4.5

T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage

The proximate composition (%DM) of ensiled fresh maize stover with different proportions of cassava foliage is shown in Table 2. There was a significant ($P<0.05$) difference in the crude protein (CP), crude fibre (CF), ash and non fibre carbohydrate (NFC). The value varied from 7.87 – 9.49 %, 19.84 – 28.77%, 9.15 – 10.79% and 20.32 – 24.85% for CP, CF, ash and NFC, respectively. Meanwhile, T6 had highest ($P<0.05$) contents of CP, CF, ash and NFC while least contents was recorded for T1. Similar ($P>0.05$) contents of DM and EE was recorded across the experimental treatments.

Table 2: Proximate composition (%DM) of ensiled fresh maize stover with different proportions of cassava foliage

Parameters	Treatments						SEM	LOS
	T1	T2	T3	T4	T5	T6		
Dry matter	88.12	88.28	88.44	88.56	88.63	88.73	0.22	NS
Crude protein	7.87 ^c	8.18 ^c	8.79 ^b	9.08 ^{ab}	9.27 ^{ab}	9.49 ^a	0.15	**
Ether ester	2.67	2.73	2.98	3.11	2.29	3.43	0.12	NS
Crude fibre	19.84 ^d	21.38 ^d	23.72 ^c	25.39 ^{bc}	27.15 ^{ab}	28.77 ^a	0.79	**
Ash	9.15 ^d	9.45 ^{cd}	9.65 ^c	9.88 ^{bc}	10.14 ^b	10.79 ^a	0.14	**
Non fibre carbohydrate	20.32 ^b	20.49 ^b	20.67 ^b	21.78 ^{ab}	23.09 ^{ab}	24.85 ^a	0.52	**

^{a, b, c, d} Means on the same row with different superscripts differ significantly ($P<0.05$); SEM= Standard; NS= Not significant; **= Significant; T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage

Table 3 indicates the fibre fractions (%DM) of ensiled fresh maize stover with different proportions of cassava foliage. There were significant ($P<0.05$) differences in the neural detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL) and cellulose. The contents varied from 51.44 – 59.67 %, 31.49 – 38.76 %, 16.25 – 19.24 % and 15.24 – 19.52, respectively. There was no significant ($P>0.05$) difference in the hemicellulose contents across the experimental treatments, the contents ranged from 19.95 – 21.14%.

Table 3: Fibre fractions (%DM) of ensiled fresh maize stover with different proportions of cassava foliage

Parameters	Treatments						SEM	LOS
	T1	T2	T3	T4	T5	T6		
Neural detergent fibre	51.44 ^e	54.21 ^d	56.15 ^c	58.26 ^b	59.18 ^{ab}	59.67 ^a	0.72	**
Acid detergent fibre	31.49 ^d	33.28 ^c	35.81 ^b	37.12 ^{ab}	38.07 ^a	38.76 ^a	0.66	**
Acid detergent lignin	16.25 ^c	17.03 ^c	18.13 ^b	18.69 ^{ab}	19.05 ^a	19.24 ^a	0.28	**
Cellulose	15.24 ^c	16.25 ^{bc}	17.68 ^{ab}	18.43 ^{ab}	19.02 ^a	19.52 ^a	0.44	**
Hemicellulose	19.95	20.23	20.91	20.93	21.11	21.14	0.31	NS

^{a, b, c, d, e} Means on the same row with different superscripts differ significantly ($P<0.05$); SEM= Standard; NS= Not significant; **= Significant; T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage

Table 4 indicates the mineral profile of ensiled fresh maize stover with different proportions of cassava foliage. There was a significant ($P<0.05$) difference in the mineral contents across the experimental treatments. The mineral contents varied from 0.23 – 0.26 %, 0.34 – 0.37 %, 0.41 – 0.44 %, 0.15 – 0.17 %, 0.25 – 0.27 %, 28.13 – 29.18 mg/kg, 159.34 – 161.24 mg/kg, 6.10 – 9.50 mg/kg and 14.20 – 17.40 mg/kg for Ca, P, K, Na, Mg, Zn, Fe, Cu and Mn, respectively.

Table 4: Mineral profile of ensiled fresh maize stover with different proportions of cassava foliage

Parameters	Treatments						SEM	LOS
	T1	T2	T3	T4	T5	T6		
Calcium (%)	0.23 ^d	0.24 ^c	0.25 ^b	0.25 ^b	0.26 ^a	0.26 ^a	0.00	**
Phosphorous (%)	0.34 ^d	0.34 ^d	0.35 ^c	0.36 ^b	0.36 ^b	0.37 ^a	0.00	**
Potassium (%)	0.41 ^c	0.42 ^{bc}	0.43 ^{ab}	0.43 ^{ab}	0.44 ^a	0.44 ^a	0.00	**
Sodium (%)	0.15 ^c	0.15 ^{bc}	0.15 ^{abc}	0.16 ^{abc}	0.16 ^{ab}	0.17 ^a	0.00	**
Magnesium (%)	0.25 ^d	0.25 ^c	0.26 ^c	0.26 ^b	0.26 ^b	0.27 ^a	0.00	**
Zinc (mg/kg)	28.13 ^d	28.34 ^c	28.81 ^b	29.06 ^a	29.11 ^a	29.18 ^a	0.10	**
Iron (mg/kg)	159.34 ^e	159.71 ^d	160.23 ^c	160.71 ^b	161.15 ^a	161.24 ^a	0.17	**
Copper (mg/kg)	6.10 ^d	6.90 ^c	7.40 ^c	8.30 ^b	8.90 ^{ab}	9.50 ^a	0.30	**
Manganese (mg/kg)	14.20 ^f	14.80 ^e	15.50 ^d	16.10 ^c	16.70 ^b	17.40 ^a	0.27	**

^{a, b, c, d, e, f} Means on the same row with different superscripts differ significantly ($P<0.05$); SEM= Standard; NS= Not significant; **= Significant; T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage

Table 5 shows the anti-nutritional factors of ensiled fresh maize stover with different proportions of cassava foliage. There were significant ($P<0.05$) differences for all the anti-nutritional factors considered across the experimental treatments. The contents varied from 0.42 – 0.46 %, 0.35 –

0.39 %, 0.47 – 0.50 %, 0.02 – 0.05%, 2.63 – 3.09 and 12.90 – 15.23, for phytate, oxalate, saponin, tannin, trypsin inhibitor and hydrocyanide, respectively.

Table 5: Anti-nutritional factors of ensiled fresh maize stover with different proportions of cassava foliage

Parameters	Treatments						SEM	LOS
	T1	T2	T3	T4	T5	T6		
Phytate	0.42 ^c	0.43 ^{bc}	0.43 ^{bc}	0.44 ^{abc}	0.45 ^{ab}	0.46 ^a	0.00	**
Oxalate	0.35 ^c	0.36 ^{bc}	0.37 ^{abc}	0.37 ^{abc}	0.38 ^{ab}	0.39 ^a	0.00	**
Saponin	0.47 ^c	0.47 ^c	0.48 ^{abc}	0.49 ^{ab}	0.50 ^a	0.50 ^a	0.00	**
Tannin	0.02 ^d	0.03 ^c	0.03 ^c	0.04 ^b	0.04 ^b	0.05 ^a	0.05	**
Trypsin inhibitor	2.63 ^e	2.74 ^d	2.86 ^{cd}	2.94 ^{bc}	3.02 ^{ab}	3.09 ^a	0.41	**
Hydrocyanide	12.90 ^d	13.56 ^c	13.94 ^c	14.37 ^b	14.89 ^a	15.23 ^a	0.20	**

^{a, b, c, d, e} Means on the same row with different superscripts differ significantly (P<0.05); SEM= Standard; T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage.

Post in vitro digestibility characteristics of ensiled fresh maize stover with different proportions of cassava foliage indicated in Table 6. The 24 hours volume of gas production, CH₄ production, dry matter digestibility (DMD), organic matter digestibility (OMD), metabolizable energy (ME), short chain fatty acid (SCFA) and fermentative efficiency (FE) were significantly (P<0.05) difference across the experimental treatments. The trend was that the inclusion levels of cassava foliage promoted better post in vitro characteristics. The values varied from 13.33 – 19.33 mL, 0.82 – 10.67 mL, 83.15 – 89.01 %, 39.33 – 65.57 %, 36.16 – 42.42 %, 4.49 – 5.36 MJ/kg DM, 0.26 – 0.40 Mmol and 2.37 – 4.95 for 24 hours. volume of gas production, CH₄ production, DMD, OMD, ME, SCFA and FE, respectively.

Table 6: Post *In-vitro* digestibility characteristics of ensiled fresh maize stover with different proportions of cassava foliage

Parameters	Treatments						SEM	LOS
	T1	T2	T3	T4	T5	T6		
24hr. GVP (mL)	13.33 ^c	14.67 ^{ab}	16.00 ^{ab}	16.67 ^{ab}	16.67 ^{ab}	19.33 ^a	0.64	**
CH ₄ (mL)	0.82 ^b	0.83 ^b	0.89 ^c	5.91 ^{ab}	10.00 ^a	10.67 ^a	0.65	**
CH ₄ Red. (%)	83.15 ^b	84.63 ^{ab}	85.34 ^{ab}	86.08 ^{ab}	88.28 ^a	89.01 ^a	0.71	**
DMD (%)	39.33 ^f	44.83 ^e	54.47 ^{cd}	56.93 ^c	62.10 ^{ab}	65.57 ^a	0.46	**
OMD (%)	36.16 ^b	38.03 ^b	38.82 ^{ab}	39.54 ^{ab}	39.96 ^{ab}	42.42 ^a	0.61	**
ME(MJ/kg DM)	4.49 ^b	4.72 ^b	4.92 ^{ab}	4.92 ^{ab}	4.98 ^{ab}	5.36 ^a	0.09	**
SCFA (Mmol)	0.26 ^b	0.29 ^b	0.32 ^{ab}	0.34 ^{ab}	0.34 ^{ab}	0.40 ^a	0.02	**
FE	2.37 ^b	2.67 ^b	2.96 ^b	3.70 ^{ab}	4.06 ^{ab}	4.95 ^a	0.30	**

^{a, b, c} Means on the same row with different superscripts differ significantly (P<0.05) SEM= Standard; NS= Not significant; **= Significant; T1 = 100% Maize stover; T2 = 90% Maize stover + 10% cassava foliage; T3 = 80% Maize stover + 20% cassava foliage; T4 = 70% Maize stover + 30% cassava foliage; T5 = 60% Maize stover + 40% cassava foliage; T6 = 50% Maize stover + 50% cassava foliage; GVP = gas volume production; CH₄ = methane gas; CH₄ Red. = methane gas reduction; DMD= dry matter digestibility; OMD= organic matter digestibility; SCFA= short chain fatty acid; FE=fermentation efficiency

Discussion

Generally, the pleasant aroma perceived in all the silage was an indication of normal physical

characteristics of good silage (Lamidi and Akhigbe, 2018). The trends of colour changes for the silages was from yellowish-green to

brownish-green as the inclusion levels of cassava foliage increased. This finding is in line with the observations of Lamidi *et al.* (2021) who reported similar trends (Olive-green to brownish-green) for ensiled *Panicum maximum* with different proportion of *Calopogonium mucunoides*. Meanwhile, the colour of the silages was close to the original colour of the grass, which was an indication of good quality silage that was well preserved (Oduguwa *et al.*, 2007; Lamidi and Ingweye, 2020). The range of pH value (4.6 – 4.9) recorded in this study showed that the silage is very good; though the value is closer to 3.81-4.90 reported by Akinbode *et al.* (2017) when sugarcane top was ensiled with broiler litter.

The temperature obtained from the silage (33 - 37°C), agreed with the report of Adesogan and Newman (2008) that silage temperatures should not be more than 37.7° C which encourages good silage fermentation, because higher temperatures reduce the quality of the silage, enhance protein degradation and reduce rapid pH decline for an efficient degradation (Amodu *et al.*, 2014).

The CP of the silages increased as the cassava foliage inclusion levels increased; this is in line with the findings of Lamidi *et al.* (2021) who reported an increasing trend of CP for silage as the proportion of *Calopogonium mucunoides* increased in the *Panicum maximum* silage mixture.

The range of CP contents recorded for the silage (7.87 – 9.49%) were above the critical lower limit (7% CP) which forage intake by ruminants and rumen microbial activity could be negatively affected (Norton, 2003). It implies that the silage would provide adequate nitrogen requirement for the rumen microorganisms to maximally digest the main components of dietary fibre leading to the production of volatile fatty acids (Lamidi and Ogunkunle, 2016) this in turn facilitate microbial protein synthesis (Lamidi and Aina,

2013) and improve the production of meat, milk, skin and hide for man uses Lamidi *et al.* (2021).

Higher levels of NDF and lignin have been reported to have negative effect on dry matter intake and dry matter digestibility (Bakshi and Wadhwa, 2004). The NDF contents (51.44 – 59.67 %) obtained for the experimental treatments is an indication that that the silage will be a useful feeding resources as good energy source in ruminant animal production as NDF is preferred measure for ruminant feeds and dietary balancing programs (Van Soest, *et al.*, 1991). However, the NDF (51.44 – 59.67 %) contents recorded in this study were less than 60% which is considered safe for acceptable intakes of forage in ruminants (Meissner *et al.*, 1991; Lamidi and Evien, 2019).

The level of ADF is an indicator of digestibility (Lamidi and Konyeha, 2020). Shroeder, (2004) stated that as the ADF content increases, forage digestibility decreases. Ball *et al.* (2007) classified forages with ADF values greater than 43.00 – 45.00% as low quality forages. Based on this, the ADF (31.49 – 38.76 %) recorded in this study, is below (43.00 – 45.00%) and implies that the silages were of high quality in term of ADF contents.

The mineral profile of the silage recorded in this study were within the dietary requirements of goat as recommended by NRC (1985) for Ca, K and Na (0.18 – 1.04, 0.50 – 0.80 and 0.04 – 0.10 % respectively). Feedstuffs containing saponins have been shown to be defaunating agent (Teferedegna, 2000) and capable of reducing methane production (Babayemi *et al.*, 2004). Hess *et al.* (2003) attributed the methane reduction ability of plants rich in saponin to their anti-protozoa effects while Rira *et al.* (2014) reported tannin's reduction of methanogenesis in sheep through its direct

effects on the activity of the methanogenic archaea.

The tannin level in silage is below 6.0% toxic level for small ruminants and it could be an added advantage as a natural additive in the diet of ruminants, since forage or feeds containing tannin have potential of forming complexes with protein as bypass protein in the rumen (Lamidi and Ojo, 2018) by diminishing rumen protein digestibility, thus improving on the availability of protein to ruminants at the lower gut. Oxalates bind calcium and are excreted through urine or form crystals which might cause kidney stones (Kubkomawa *et al.*, 2016).

The gas production is a nutritionally wasteful product (Mauricio *et al.*, 1999) but provides a useful basis from which ME, OMD and SCFA may be predicted (Fajemisin *et al.*, 2015). Meanwhile, low gas production is an indication of low degradability. Gas produced in *in-vitro* fermentation reflects the extent of feed fermentation and digestibility. Increase in the amount of protein available to microorganism is positively related to gas production according to the reports of Oni *et al.* (2019) who asserted that gas production is positively related to microbial protein synthesis. The range of the *in vitro* DMD (39.33 – 65.37%) recorded for silage in the present study was within that (39.33 – 65.57%) reported for ensiled fresh maize stover and groundnut haulms by Lamidi and Ingweye (2020). This shows that ensiling cassava foliage with guinea grass has great nutritional advantages like other legume foliage.

Conclusion and recommendations

The physical features, proximate composition, fibre fractions, anti-nutritional factors, mineral contents and post *in vitro* characteristics of the experimental treatments showed that ensiled cassava foliage with maize stover has a great potential to solve the problem of dry season

feeding of ruminant. Meanwhile, 30, 40 and 50% inclusion levels of fresh cassava foliage (FCF) gave better result. It is therefore recommended that 50% FCF inclusion with maize stover can be ensiled for sustainable ruminant production.

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