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IN VITRO DIGESTIBILITY AND NUTRITIONAL ASSAY OF YAM PEELS ENSILED WITH BROWSES

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ABSTRACT
This study was conducted to determine the proximate composition and in vitro digestibility of yam peels ensiled with some leaf meals as alternative feedstuffs for ruminants. Yam peels and Gmelina arborea leaves were ensiled as Treatment 1 (T1), Yam peels + Mangifera indica leaves as Treatment 2 (T2), Yam peels + Nuclea latifolia leaves as Treatment 3 (T3), Yam peels + Elaeis guineensis leaves as Treatment 4 (T4) and Yam peels + Leucaena leucocephala leaves as Treatment 5 (T5) for 28days in five plastic buckets. They were wilted for 24hours, chopped, compressed into the plastic buckets and sealed. The result showed significant differences (P<0.05) in the CP, CF and NFE percentages of the silages. CP was highest in T5 (17.88%). Potassium, iron, zinc and copper differed significantly (P<0.05). Potassium (%) was highest in T5 (0.74%). There were significant differences (P<0.05) in all the fibre fractions of the silages. The metabolisable energy (ME), organic matter digestibility (OMD) and short chain fatty acid (SCFA) of the silages differed significantly (P<0.05). ME was highest in T5 (5.85MJ/kg) and T3 (5.55MJ/kg). OMD was highest in T5 (45.46%) and lowest in T4 (39.99%), T2 (40.12%) and T1 (40.27%). SCFA was highest in T5 (0.40umol/200mgDM), T3 (0.40umol/200mgDM) and T1 (0.44umol/200mgDM). T2, T3, T4 and T5 had CP contents above 7% and can be used to feed ruminants but T5 proved superior.

Keywords: Fibre fraction, metabolisable energy, mineral content, organic matter digestibility and saponin

Introduction

The major problem facing livestock production in Nigeria is the scarcity of feed especially in the dry season when forages become lignified and innutritious (Areghare, 2000; Ukanwoko and Okpechi, 2016). This results in poor utilization and performance by ruminants in terms of productivity. To bridge this gap, ruminants can be fed with crop residues and browses which serve as alternative feedstuffs in the dry season. Browses are high in nutrients: protein, minerals and vitamins (Babayemi *et al*., 2003; Amodu and Otaru, 2004). Browses when given to ruminants enhance productivity and reduce cost of production. Browses are known to enhance intake of poor quality roughages, improve growth rates and increase reproductive efficiency in small ruminants (Asaolu *et al*., 2011). Yam (*Dioscorea spp*) peels constitute about 10% of the yam tuber (Ijaiya and Awonusi, 2005) and have been reported to be successfully fed to sheep and goats (Ekenyem *et al*., 2006). Their crude protein content is between 2 – 6% while their crude fibre content ranges from 9 – 15% depending on the variety (Akinmutimi *et al*., 2006). Small ruminants have been reported to be prolific, breeding throughout the year (Chukwuka *etal*., 2010). Compared to cattle, goats can be raised with low feed requirement (Tsado *et al*., 2009) and this can go a long way in alleviating the problem of low protein intake in Nigeria (Adeokun *et al*., 2008). This in turn calls for increased approach towards small ruminant animal production and the need for silage production

Materials and Methods

Location of study

The experiment was carried out in the University of Port Harcourt Research and Demonstration Farm, Choba, Obio/Akpor Local Government Area of Rivers State in the South-South zone of Nigeria. It falls within the humid rain forest zone of West Africa with long duration of rainfall (March - November) and a very short dry season precipitation that occurs during September with an average of 367 mm of rain in 182 rain days with a temperature range of 25 - 28^{0}C, a very high relative humidity (above 80 % rainfall (March-November) and a very short dry season precipitation which occurs during September

with an average of 367 mm of rain in 182 rain days, temperature range of 25 - 28^{0}C and a very high relative humidity (above 80 %).

Data collection

Fresh leaves of browses (*Gmelina arborea, Nauclea latifolia, Elaeis guinensis,Leucaena leucocephala* and *Mangifera indica)* were harvested from the school premises at Choba campus, wilted overnight and chopped into 3 - 4cm long pieces. Yam peels were collected from processing or selling points within and around the University campus. The yam peels were mixed with *Gmelina arborea, Nauclea latifolia, Elaeis guinensis,Leucaena leucocephala* and *Mangifera indica* leaf meals.

Treatment 1: 50% Yam peels + 50% *Gmelina arborea* leaf meals.

Treatment 2: 50% Yam peels + 50% *Mangifera indica* leaf meals.

Treatment 3: 50% Yam peels + 50% *Nuclea latifolia* leaf meals.

Treatment 4: 50% Yam peels + 50% *Elaeis guineensis* leaf meals.

Treatment 5: 50% Yam peels + 50% *Leucaena leucocephala* leaf meals

Five paint plastic buckets were used as laboratory silos for the five treatments; the cut *Gmelina arborea, Nauclea latifolia, Elaeis guineensis, Leucaena leucocephala* and *Mangifera indica* leaves with yam peels were loaded into the silos, compressed and sealed to prevent air from entering the silo. The treatments were replicated three times. After 30 days, the containers were opened and the physical properties such as odour, mouldiness, colour changes and moistness were determined by rating the quantities using the physical characteristics rating scale shown in Table 1.

Table 1: Physical characteristics rating scale

Scale	Mouldiness	Odour	colour	moisture
1	Without mould	Pleasant	Light greenish brown	No moisture
2	Slightly mouldy	Fairly pleasant	Greenish brown	Slightly moist
3	Averagely mould	Averagely pleasant	Dark brownish green	Averagely moist
4	Highly mouldy	Slightly pungent	Brown	Heavily moist
5	Black spores	Pungent	Dark brown	Completely moist

Source: adapted from Hassan (2004)

Data analysis

Crude protein content was determined using Kjeldahls' method of nitrogen determination. Ether extracts (EE) were determined using the Soxhlet extractor. Crude fibre (CF) was determined using the Weende's method and nitrogen free extract was determined by adding crude protein, fat, water, ash, and fibre and the sum subtracted from 100, the difference is NFE = DM– (%Moisture + %CF + %CP + % EE + %Ash). The anti-nutritional factors (saponins, tannins and phytate) and the mineral content (calcium, potassium, sodium, magnesium and phosphorus) were also analysed. The presence of Tannins was determined by adding 2ml of 5% ferric chloride to plant extract, the presence of saponins was determined by the addition of 2ml distilled water to plant extract and shaken in a graduated cylinder for 15minutes and phytate was determined by adding equal volume of chloroform to plant extract and subjecting with few drops of concentrated sulphuric acid. Sodium, potassium, calcium and magnesium were determined with anautomatic atomic absorption spectrophotometer and total phosphorus was determined spectrophotometrically after incubation with molybdo-vanadate solution (AOAC, 2005).

Rumen liquor collection for in vitro study

Rumen liquor was collected from goats housed at the University of Benin Teaching and Research farm, Ugbowo Campus, Benin City. The collection was via stomach tube. The liquor was collected in the early hours of the morning into a pre warmed flask prior to feeding the animals. The flask containing the rumen liquor was taken to the laboratory where it was strained through four layers of cheese cloth. The strained liquor was mixed with a buffer solution in a ratio of 1:2. This mixture was put in a water bath and gassed with CO_2 to maintain anaerobic condition and a temperature of 39°C to keep the microorganisms alive.

Buffer preparation

The buffer was prepared a day before the rumen liquor collection and maintained at a pH of 6.2 (Navaro-ville *et al.,* 2011) and temperature of 39^{o}C. The buffer used consists of the following reagents:

Na_2HPO_4. $12H_2O$	1.985g/l
KH_2PO_4	1.302g/l
$MgCl_2.6H_2O$	0.105g /l
NH_4HCO_3	1.407g /l
$NaHCO_3$	5.418g /l
NaOH	0.100g /l

In vitro fermentation of samples

The *in vitro* incubation was carried out using 120 ml calibrated syringes containing the inoculums (Rumen liquor: buffer, 1:2). 200 mg of substrate was weighed into nylon bags for the incubation at 39^{o}C with 30 ml of inoculums. A 0.1g of each sample was added prior to sealing the bags. The bags were placed inside the syringes before the inoculum was introduced into the syringes. The syringes were fitted with silicon tube

and clipped before placing them in the incubator at 39°C. The syringes containing only inoculum served as the blank while the bags containing only the substrate served as the control. The time for the commencement of incubation was noted and the syringes were monitored at three hour intervals for the next 24 hours. For each incubation time, the head space of the syringes was measured and recorded. At 24 hours of incubation, the final readings were taken and the syringes put on ice to stop further gas production.

Determination of post in vitro parameters (DMD, FE, SCFA, ME and OMD)

The sealed nylon bags containing the sample were taken out from the syringes, washed with water and oven dried at 100°C to constant weight. The dry matter determined is expressed as the percentage of the original sample weighed. To calculate dry matter digestibility (DMD), the formula is expressed thus:

$$\text{DMD \%} = \frac{\text{Wt of sample before incubation} - \text{Wt of sample after incubation}}{\text{Wt of sample before incubation}} \times \frac{100}{1}$$

methane reduction (CH_4%) were calculated using the following formulas

$$\text{Fermentation Efficiency (FE)} = \frac{\text{Dry matter Digestibility (g/kg)}}{\text{Total Gas Volume (mL/g)}}$$

The post incubation parameters such as metabolisable energy (ME), Organic matter digestibility (OMD), Gas volume and Short chain fatty acids (SCFA) was estimated using the equation below:

ME= 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF (Menke and Steingass, 1988).

OMD = 14.88 + 0.88 GV + 0.45 CP + 0.651 XA (Menke and Steingass, 1988).

SCFA = 0.0239 GV – 0.0601 (Getachew *et al.*, 1999), where

GV, CP, CF and XA are total gas volume, Crude protein, Crude Fibre and ash of the incubated samples respectively.

Experimental design

The study was conducted using a completely randomize design (CRD).

Chemical analysis

Samples of the silages were analyzed for proximate composition using the general procedures of AOAC (2000) while detergent fibre was determined by the procedures of Van Soest *et al* (1991).

Statistical analysis

The data obtained in this study were subjected to one way analysis of variance (ANOVA). Difference between means was determined with the Duncan's multiple range test (Duncan, 1955) using the Statistical Package for Social Sciences (SPSS) software.

Results and Discussion

The results of the physical properties of the silages are presented in Table 2. All the silages were greenish brown in colour, had pleasant odour and without mould. Yam peels with *Mangifera indica* leaves silage (T_2) had no moisture while the other silages were slightly moist.

Table 2: Physical properties of the silage

Properties	**Types of Silages**				
	1	**2**	**3**	**4**	**5**
Colour	2	1	1	1	1
Moisture	2	1	2	2	2
Odour	2	2	1	2	2
Mouldiness	1	1	1	1	1

1 = Yam peels with *Gmelina arborea* leaves, 2 = Yam peels with *Mangifera indica* leaves, 3 = Yam peels with *Nuclea latifolia* leaves, 4 = Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaena laecocephala* leaves.

The proximate composition of the silages is presented in Table 3. There were significant differences ($P<0.05$) in the crude protein contents of the silages. T_5 had the highest CP content of 17.88% while T_1 had the least (3.69%). The CP content of 17.88% reported for *Leucaenaleucocephala* silage in this study was lower than a CP content of 24.75% reported by Ukanwoko and Ukandu (2012) and a CP range of 24 – 30% reported by Garcia *et al* (2008) for fresh Leucaena. Generally, there tends to be a decline in nutrient composition after silages are made, 75% of the nutrients are conserved (Obua, 2005). There were significant differences ($P<0.05$) in the CF and NFE contents of the silages. The highest CF content was recorded in T_4 (18.37%) and the lowest in T_3 (13.89%). The CF content of 18.37% recorded by T_4 yam peels ensiled with *Elaeis guinensis* is higher than a CF of 16.29% reported by Ukanwoko *et al* (2013) for *Elaeisguinensis* and that reported by Esonu *et al* (2008). The highest NFE value was recorded in T_1 (55.12%) while the lowest was recorded in T_5.

The mineral composition of the silages is presented in Table 4. There were significant differences (P<0.05) in the potassium, iron, zinc and copper contents of the silages. The highest potassium content of 0.74% was recorded in T_5.

Table 3: Proximate composition of the silage

	Parameters (%)						
Treatments	**CP**	**FE**	**CF**	**ASH**	**M**	**DM**	**NFE**
1	3.69^{e}	3.39	17.26^{b}	7.62	12.92	87.08	55.12^{a}
2	16.78^{b}	3.69	15.46^{c}	8.21	12.83	87.17	42.99^{c}
3	12.67^{d}	3.18	13.89^{d}	7.87	13.34	86.66	49.05^{b}
4	14.29^{c}	3.23	18.37^{a}	7.98	13.17	86.83	42.96^{c}
5	17.88^{a}	3.78	16.89^{b}	8.49	12.59	87.41	40.37^{d}
SEM	**1.34**	**0.12**	**0.42**	**0.13**	**0.13**	**0.13**	**1.43**

^{abc} Mean between row that bear different superscripts differ significantly.
Treatments: 1 =Yam peels with *Gmelina arborea* leaves, 2 = Yam peels with *Mangifera indica* leaves, 3 = Yam peels with *Nuclea latifolia* leaves, 4 = Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaena laecocephala* leaves

The mineral composition of the silages is presented in Table 4. There were significant differences (P<0.05) in the potassium, iron, zinc and copper contents of the silages. The highest potassium content of 0.74% was recorded in T_5. This compares favourably with the potassium content of 0.83±0.10% reported by Okwu and Ezenagu (2008) for *Leucaena* leaves but lower than 3.48% potassium content reported by Aye and Adegun (2013). The highest iron content was recorded in T_5 (156.45mg/kg) while the least was in T_2 (118.70mg/kg). The highest iron content recorded in this study for T_5 is higher than the iron content of 136mg/kg reported by Feedipedia.org for *Leucaena* but far lower than that (365mg/kg) reported by Uemura *et al* (2014) for *Leucaena*. T_5 also had the highest Zinc content (61.30mg/kg). This is higher than 7.88±0.10mg/kg and 30.4mg/kg Zinc contents reported by Okwu and Ezenagu (2008) and Uemura *et al* (2014) respectively for *Leucaena*. T_5 had the highest copper content of 8.10mg/kg. This compares favourably with the copper content of 8.68±0.10mg/kg reported by Okwu and Ezenagu (2008) for *Leucaena* but lower than 9.4mg/kg of copper reported by Uemura *et al* (2014) for *Leucaena*.

Table 4: Mineral composition of the silages

	Parameters						
Treatments	**%Na**	**%K**	**%Ca**	**%P**	**Fe (mg/kg)**	**Zn (mg/kg)**	**Cu (mg/kg)**
1	0.23	0.37^{c}	0.22	0.38	134.80^{c}	51.40^{c}	7.30^{a}
2	0.22	0.53^{b}	0.21	0.35	118.70^{e}	43.20^{e}	5.30^{e}
3	0.23	0.56^{b}	0.22	0.37	129.80^{d}	48.70^{d}	6.40^{d}
4	0.24	0.58^{b}	0.23	0.38	137.70^{b}	52.50^{b}	6.90^{c}
5	0.31	0.74^{a}	0.28	0.42	156.45^{a}	61.30^{a}	8.10^{a}
SEM	**0.01**	**0.03**	**0.01**	**0.01**	**3.29**	**1.57**	**0.24**

^{abcde} Mean between row that bear different superscripts differ significantly.
Treatments: 1= Yam peels with *Gmelina arborea* leaves, 2 = Yam peels with *Mangifera indica* leaves, 3 =Yam peels with *Nuclea latifolia* leaves, 4 =Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaena laecocephala* leaves.

The anti-nutritional contents of the silages are presented in Table 5. There were no significant differences (P>0.05) in the anti-nutritional contents of the silages. The tannin values of 0.002 – 0.006% reported in this study were within tolerable levels for ruminants as Onyeonagu and Njoku (2010) reported a tannin level of 2% as a safe range for ruminants. The saponin levels of 0.32 – 0.78% observed in this study were within tolerable levels as reported by Anhwange *et al* (2009).

Table 5: Anti nutritional factor of the different silage

Treatments	Saponin	Phytate	Oxalate	Tannin
1	0.68	0.24	0.18	0.002
2	0.42	0.21	0.16	0.004
3	0.32	0.23	0.18	0.002
4	0.78	0.25	0.19	0.003
5	0.53	0.20	0.15	0.006
SEM	**0.06**	**0.02**	**0.01**	**0.001**

Treatments 1 = Yam peels with *Gmelina arborea* leaves, 2 = Yam peels with *Mangifera indica* leaves, 3 = Yam peels with Nuclea *latifolia* leaves, 4 = Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaena laecocephal*a leaves.

The fibre fractions of the silages are presented in Table 6. There were significant differences (P<0.05) in the NDF, ADF, ADL, hemicellulose and cellulose contents of the silages. The highest NDF percentage was recorded in T_4 (58.62%). This is higher than that (53.82%) reported by Suyitman *et al* (2018) but lower than that (63 – 80%) reported by Aim-oeb *et al* (2008) for oil palm fronds. The highest ADF percentage was recorded in T_4 (45.26%). This is lower than the ADF percentage of 52.6% reported by Kawamoto *et al* (2001) but higher than that (41.34%) reported by Suyitman *et al* (2018) for oil palm fronds. The highest ADL percentage was recorded in T_4 (19.38%). This compares favourably with the ADL percentage of 19.90% reported by Kawamoto *et al* (2001) but lower than that (12.37%) reported by Islam *et al* (2000) for oil palm fronds. The highest hemicellulose percentage was recorded in T_5 (14.24%). This is lower than the hemicellulose percentages of 18.70% and 37.13% reported by Aye and Adegun (2013) and Alaba *et al* (2011), respectively for *Leucaena leucocephala* leaves. The cellulose percentages in T_1 (25.96%), T_2 (25.68%) and T_4 (25.88%) were similar (P>0.05) but higher than those in T_3 (24.06%) and T_5 (24.26%). The cellulose percentage of 24.26% reported in T_5 in this study is lower than that (56%) reported by Oni *et al* (2014) But higher than that (20.59%) reported by Alaba *et al* (2011) for *Leucaena* leaves.

Table 6: Fiber fractions of the silage

Treatments	%NDF	%ADF	%ADL	%Hemicellulose	%Cellulose
1	57.48^{b}	43.81^{b}	17.85^{b}	13.67^{ab}	25.96^{a}
2	58.52^{a}	44.06^{b}	17.58^{b}	13.16^{b}	25.68^{a}
3	51.28^{d}	38.15^{d}	13.89^{d}	13.13^{b}	24.06^{b}
4	58.62^{a}	45.26^{a}	19.38^{a}	13.36^{ab}	25.88^{a}
5	55.29^{c}	41.05^{c}	16.79^{c}	14.24^{a}	24.26^{b}
SEM	**0.74**	**0.74**	**0.55**	**0.14**	**0.24**

^{abc} Mean between row that bear different superscripts differ significantly.
Treatments 1= Yam peels with *Gmelina arborea* leaves, 2= Yam peels with *Mangifera indica* leaves, 3 = Yam peels with *Nuclea latifolia* leaves, 4= Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaena laecocephala* leaves. NDF = Neutral detergent fibre, ADF = Acid detergent fibre and ADL = Acid detergent lignin

The *in-vitro* gas characteristics of the silages are presented in Table 7. There were significant differences (P<0.05) in the ME contents of the silages. T_5 (yam peels ensiled with *Leucaenaleucocephala* leaves) had the highest ME (5.85MJ/Kg). This is lower than that reported by Babayemi *etal* (2009) for *Leucaena*. There were significant differences (P<0.05) in the OMD values of the silages. The highest was recorded in T_5 (45.46%) which is lower than the OMD values of 47.43% and 57.20% reported by Putra *et al* (2017) and Babayemi *et al* (2009), respectively. There were also significant differences (P<0.05) in the SCFA values produced by the silages. The values in T_1, T_3 and T_5 were similar but higher than the values recorded in T_2 and T_4. Babayemi *et al* (2009) reported a SCFA value of 0.95umol/200mgDm for *Leucaenaleucocephala* and this is higher than that (0.40) reported in this study for T_5 (Yam peels ensiled with *Leucaena leucocephala* leaves).

Table 7: *Invitro* gas characteristics of the different silages

Treatments	CH_4	DMD	FE	ME	OMD	SCFA
1	10.00	33.74	1.58	5.31^{bc}	40.27^{c}	0.44^{a}
2	6.67	26.01	1.85	5.06^{c}	40.12^{c}	0.27^{b}
3	10.00	33.07	1.17	5.55^{ab}	42.71^{b}	0.40^{a}
4	8.67	26.65	1.75	5.10^{c}	39.99^{c}	0.30^{b}
5	8.00	30.07	1.55	5.85^{a}	45.46^{a}	0.40^{a}
SEM	0.72	1.20	0.05	0.08	0.62	0.01

^{abc} Mean between row that bear different superscripts differ significantly.

Treatments 1 =Yam peels with *Gmelina arborea* leaves, 2= Yam peels with *Mangifera indica* leaves, 3= Yam peels with *Nuclea latifolia* leaves, 4= Yam peels with *Elaeis guineensis* leaves, 5 = Yam peels with *Leucaenalaecocephala* leaves. CH_4 = methane, DMD = Dry matter digestibility, FE = Fermentation efficiency, ME = Metabolisable enrgy, OMD = Organic matter digestibility, SCFA = Short chain fatty acid

Conclusion

Treatments; T_2, T_3, T_4 and T_5 had CP percentage well above the 7% recommended for ruminants but T_5 proved superior in terms of its mineral contents, metabolisable energy and organic matter digestibility. Therefore T_5, the yam peels ensiled with *Leucaena leucocephala* leaf meal is recommended for ruminant animal producers.

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