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Effects of ensiling on the physical properties, chemical composition and mineral contents of guinea grass and cassava tops silage

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Abstract

An experiment to determine the effects of ensiling on the physical properties, chemical composition and mineral contents of guinea grass and cassava tops silage was carried out between January and April, 2004. Cassava (Manihot esculentus var. Texas Cranz) tops and guinea grass (Panicum maximum Jacq var. Ntchisi) were ensiled alone and in mixture using plastic containers lined with polythene sheets. The experiment was a completely randomised design with three replicates comprising of the three plant mixtures i.e. cassava silage, guinea grass silage and mixture of the two. The result of the experiment showed that the silage from the three plant mixtures was similar physically. Although, ensiling reduced the DM and CP contents slightly, the lower pH of between 3.92 and 4.38 showed that the silage was well preserved with improved quality due to the drastic reduction in hydrocyanide (HCN) content of cassava tops. Mixing guinea grass and cassava top produced average qualities especially in terms of the structural carbohydrates such as ADF, NDF and lignin with HCN content reduced and increased CP content (25.48%) and minerals. Other properties such as DM, moisture, ash, organic matter, cellulose, hemicellulose, gross energy and pH were not significantly different in the silages from the three plant mixtures i.e. guinea grass, cassava tops and mixture of guinea grass and cassava tops. It was concluded that mixing guinea grass with cassava tops improved the quality of silage produced than ensiling any of them sole.

Key words: Guinea grass, cassava tops silage, physical properties, chemical composition, and mineral contents

Introduction

McDonald *et al.*, (1995) defined silage as a material produced by controlled fermentation of a crop of high moisture content. The first essential objective in preserving crops by natural fermentation is the achievement of anaerobic condition. Ensiling is the name given to the process (McDonald *et al.*, 1995). In practice, this is done by chopping the crop during harvesting, by rapid filling of the silo and adequate consolidation and sealing. The main aim of this air-tight sealing is to prevent re-entry and circulation of air during storage.

The nutritional value of silage depends primarily on the species and stage of growth of harvested crop as well as changes resulting from the activities of plant enzymes and micro organisms during harvesting and storage period. Immediately after cutting the crop and during the early stages of ensiling, chemical changes occur resulting from the activity of enzymes present in the plant tissue. The processes of respiration and proteolysis are of particular importance influencing nutritional value of the final product since silage is produced through anaerobic fermentation. Cassava leaves have been found to be rich in proteins, minerals and vitamins and all essential amino acids except methionine and phenylalanine (Ravindran, 1993; Eruvbetine, 1995). However, cassava leaves contains two cyanoglucosides; linamarin and methyllinamarin in the ratio of 96:4 which undergoes hydrolysis by an analogous hydrocyanic acid (HCN) (Nestle and MacIntyre, 1973) which therefore limit leaf utilization. However, with proper processing techniques, these problems can be eliminated (Lancaster *et al.*, 1982; Gomez and Validivieso, 1985). Hay of cassava foliage and stem showed potential as good feed resources for ruminant animals with a high voluntary feed intake and dry matter digestibility (71%) as reported by Wanapat *et al.* (1997). Traditionally, cassava (*Manihot esculenta* Crantz) has been cultivated almost exclusively for tuber production for human consumption, while their foliage has mainly been considered as a residue. Cassava is a widely grown crop in most countries in the tropical regions of Africa, Latin America and Asia, and ranks as one of the main crops in the tropical countries. Cassava leaf yields may be as high as 4 - 6 tonnes dry matter (DM) per ha and are considered as a by-product after root harvest (Ravindran and Rajaguru, 1988).

In other to explore the benefits from cassava as ruminant feed resources, as well as increase the use of cassava tops and also to reduce the effects of the hydrocyanic glucoside, different methods can be used for preservation especially sun drying can be exploited (Brown and Charalimu, 1985; Phuc *et al.*, 2001). However in the rainy season, when cassava leaves are in excess, it is difficult to sun-dry, and extending the drying process diminishes the nutritional quality of the product. Ensiling or high temperature (50°C) drying has an advantage over sun drying in this respect (Phuc *et al.*, 2001).

Considering the importance of cassava leaves as source of protein and also the poisonous hydrocyanic glucoside, it is pertinent to consider the effects of ensiling in mixture with grasses such as guinea grass (*Panicum maximum* Jacq.). Therefore, the aim of this study was to determine the effects of ensiling cassava leaves with Guinea grass on the physical properties, chemical composition and mineral contents of the silage produced.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm, University of Agriculture, Abeokuta, Nigeria (Lat 62 20°N, 202 41°E). Cassava (*Manihot esculentus* var Texas) tops and guinea grass (*Panicum Maximum* Jacq) were ensiled as sole and mixture in plastic containers lined with polythene sheet. The cassava tops were harvested from plants established from the Farm Practical Year (FPY) training programmes at about 6 – 8 months old, the parts collected for the experiment includes the green stem and it's leaf canopy with an average of 20 – 25 cm long to the top which was about 50cm to the ground level. Fresh guinea grass (*Panicum maximum* var Ntchisi Jacq.) at the vegetative stage (8 weeks of re growth) was harvested from the oil palm plantation of the University of Agriculture, Abeokuta. The plants were chopped into pieces of about 3 - 4cm length. The chopped stems were partially wilted for 5hours to reduce the moisture content. One (1) kg of cassava and guinea grass were measured separately into separate plastic containers and 0.5kg of cassava and guinea grass each was measured together into one container as mixtures. The treatments were replicated three (3) times. The materials were compressed into the containers to ensure maximum elimination of air and they were covered with polythene sheets and compressed with heavy stones. Wet weights of materials were taken before ensiling.

At 30 days of ensiling, the containers were opened and the physical properties such as mouldiness, odour, colour changes and moistness were determined by rating the qualities using scale of 1 - 5 as shown on Table 1. The silage produced in each container was then weighed and samples of the silage were collected after weighing and oven-dried at 60°C for 3 days for dry matter (DM) yield estimation. The samples were ground in the Laboratory with hammer mill of 1mm sieve and subjected to chemical analysis for the determination of crude protein (CP), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), lignin, and ash following AOAC, (1995) techniques. The NDF and ADF were determined through residual ash assay (Van Soest and Robertson, 1980). Gross energy contents of the samples were determined by means of an Adiabatic bomb calorimeter and hydrocyanide (HCN) content was determined using procedures described by AOAC (1995). Hemicellulose and cellulose were calculated from the crude fibre fractions. The experimental design was a completely randomized design with three (3) replicates. The data obtained were subjected to one-way analysis of variance (ANOVA) using Minitab (1998) computer package.

Table 1: Scale for the ratings of physical properties

	Physical properties			
Scale	Mouldiness	Odour	Colour	Moistness
1	Without mould	Pleasant	Greenish	Without moist
2	Slightly mouldy	Fairly Pleasant	Greenish brown	Slightly moist
3	Averagely mouldy	Averagely pleasant	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) and modified.

Table 2: Effects of plant types on physical properties

Physical	Plant types		
Properties	SC ± SD	SG ± SD	MCG ± SD
Colour	3.00 ± 1.12^{b}	2.56 ± 0.73^{c}	3.33 ± 0.87^{a}
Moistness	2.89 ± 0.78^{ab}	1.22 ± 0.44^{c}	3.22 ± 0.83^{a}
FW?	0.53 ± 0.24^{b}	0.85 ± 0.28^{a}	0.34 ± 0.04^{c}
Mouldiness	2.22±0.67	2.33±0.71	2.67±0.50
Odour	2.89±1.45	3.78±1.40	2.11 ± 0.33

*Means in the same row with different superscripts are significantly different (P<0.05)
SC =Cassava tops alone
SG=Guinea grass alone
MCG =Mixture of cassava tops and Guinea grass
FWΔ = change in fresh weight after ensiling

Results and Discussion

Physical properties

There were significant ($P<0.05$) differences in the physical properties of the silage produced from the different plant types except mouldiness and odour (Table 2). Silage produced from cassava leaves alone was brownish green (3.00) with those from guinea grass alone more greenish (2.56) and those from mixture of cassava tops and guinea grass more brownish (3.33). There was more moisture in mixture of cassava top and guinea grass silage (3.22) than silage from cassava tops alone (2.89) and guinea grass alone (1.22). Guinea grass silage had the least moisture and therefore the least average change in fresh weight. This may be because guinea grass wilted faster than cassava leaves when pre wilted before ensiling. Physically, when the plants were allowed to wilt for just 5hours under shade, cassava tops were still turgid when guinea grass had changed.

Generally, in terms of acceptability of silage to animals, the most important physical characteristic is odour but these physical properties helped us to determine well preserved silage. These physical qualities especially colour were similar to those obtained by Man and Wilktorsson (2002) without the addition of molasses at 2 months after ensiling. Based on the colour, odour, mouldiness and level of moistness, all the silage can be considered to be well prepared but, more important considerations have to be given to their chemical properties.

Chemical properties

There were significant differences ($P<0.05$) in the NDF, ADF, lignin, CP, and HCN contents of the silage produced from the different plant types. But, the DM, moisture, ash, organic matter content, cellulose, hemicellulose, gross energy and pH contents were not significantly different ($P>0.05$) (Table 3). Silage produced from sole guinea grass had the highest NDF, ADF, and lignin content of 70.94%, 49.97%, and 24.62% respectively while, sole cassava tops ensiled had the least contents of the chemical constituents.

Table 3: Effect of plant types on the chemical composition of silage produced

Chemical	Plant types		
Properties	SG ± SD	SC ± SD	MCG ± SD
DM%	93.17 ± 0.49	91.98 ± 2.68	93.27 ± 1.07
Moisture %	58.84 ± 24.06	57.56 ± 19.15	59.24 ± 7.34
Ash%	7.40 ± 0.62	8.20 ± 0.54	7.83 ± 0.43
NDF%	70.94 ± 1.83^{a}	48.93 ± 1.99^{c}	64.19 ± 10.90^{b}
ADF%	49.97 ± 2.08^{a}	26.80 ± 1.26^{c}	44.66 ± 8.78^{b}
Organic matter%	92.60 ± 0.62	91.81 ± 0.55	92.17 ± 0.43
Cellulose%	25.35 ± 1.18	12.72 ± 8.39	22.96 ± 9.51
Hemicellulose%	21.11 ± 0.43	22.11 ± 1.56	19.34 ± 13.32
Gross energy (Kcal/kg)	3.5487±0.1673	2.8030±0.0557	3.7920±0.0548
PH	3.35 ± 2.24	3.84 ± 0.32	3.13 ± 2.09
Lignin%	24.62 ± 0.90^{a}	18.70 ± 0.37^{c}	21.70 ± 3.62^{b}
HCN (mg/kg)	9.45 ± 18.90^{c}	121.77 ± 22.32^{a}	108.00 ± 17.08^{ab}
CP%	17.25 ± 0.08^{c}	18.73 ± 2.17^{bc}	25.48 ± 3.12^{a}

*Means in the same row with different superscripts are significantly different ($P<0.05$)

SC =Cassava tops alone; SG=Guinea grass alone

MCG =Mixture of cassava tops and guinea grass

But, silage from guinea grass had the least content of HCN and CP of 9.45% and 17.25% respectively with the highest HCN in silage from cassava tops with 121.77% and the highest CP in the mixture of guinea grass and cassava tops (25.48%). The least NDF was in ensiled cassava tops while the highest NDF content was in ensiled Guinea grass alone than both mixture of cassava top and guinea grass. Ensiled cassava tops alone had lower NDF content of 48.90% which is 31.03% lower than ensiled guinea grass alone (70.90%) and 23.83% lower than mixture of guinea grass and cassava tops. Man and Wiktorsson (2001) also obtained similar lower NDF and ADF contents in cassava tops than guinea grass but found lower lignin content in guinea grass than cassava tops, which was contrary to the results obtained in this study. The differences in the lignin content of this study may be due to the type of guinea grass and the stage of harvest of the grass. The lower CP content in guinea grass silage compared to cassava tops silage was also similar to the findings of Man and Wilktorsson, 2001. There was a reduction in the mean HCN content, from 121.77mg/kg in cassava tops silage to 108.00mg/kg in mixture of guinea grass and cassava tops silage. This shows that inclusion of guinea grass to cassava at equal weight will reduce the HCN content of silage produced by 11.31%.

Mineral content

There were significant differences in the mineral contents of silage produced from all the different plant types except manganese and calcium (Table 4). Mixture of cassava tops and guinea grass silage had the highest quantity of all the minerals while, guinea grass silage had the least quantity of all the minerals except magnesium and phosphorus. The quantity of copper, iron and potassium in the mixture of cassava tops and guinea grass silage was almost double that of guinea grass silage. The manganese and magnesium contents of silage from the different plant types were lower than the critical levels required by animals as stated by McDowell, 1985 (Table 5). The manganese contents of silage from the plant types were almost half of the critical level required by ruminant animals. The copper contents were higher than the critical level with the copper contents of cassava tops doubling the critical level and the guinea grass and cassava tops silage triple that of critical level. The Ca/P ratio was above the range required by sheep (1.0 – 1.6) only in cassava top silage (2.07) (Fujihara *et al.*, 1995).

Table 4: Effects of plant types on mineral content of silage produced

Minerals	Plant types		
(mg/100g)	SG ± SD	SC ± SD	MCG ± SD
Mn	1.36 ± 0.25	1.51 ± 0.25	1.53 ± 0.21
Cu	1.58 ± 0.34^{c}	2.44 ± 0.89^{b}	3.40 ± 0.22^{a}
Fe	17.41 ± 2.76^{b}	32.58 ± 9.71^{a}	35.42 ± 7.89^{a}
Mg	48.85 ± 9.74^{b}	44.67 ± 3.79^{b}	56.41 ± 4.89^{a}
K	688.0 ± 89.1^{c}	1626.0 ± 179.3^{b}	1728.7 ± 283.6^{a}
P	1114.0 ± 73.7^{a}	410.2 ± 543.9^{b}	1215.7 ± 50.2^{a}
Ca	120.5 ± 145.1	854.5 ± 591.6	1351.0 ± 141.2

Table 5: Comparison of mineral composition of silage from different containers and critical levels

Plant types	Mn	Cu	Fe	Mg	K	P	Ca	Ca/P
		Mg/kg				%		
Critical levels*	30-40	10	30	0.2	0.2	0.25	0.3	1.0-1.6
SG	13.6	15.8[c]	174.1[b]	0.049	0.69[b]	1.11	1.21	1.09
SC	15.1	24.4[b]	335.8[a]	0.045	1.63[a]	0.41	0.85	2.07
MCG	15.3	34.0[a]	354.2[a]	0.056	1.73[a]	1.21	1.35	1.12

*Critical levels: Source: McDowell, 1985
Means in the same row with different superscripts are significantly different ($P < 0.05$).
SC =Cassava tops alone; SG=Guinea grass alone; MCG =Mixture of cassava tops and guinea grass

Conclusion

Mixture of cassava tops and guinea grass had the darkest colour but, they were all between greenish brown and brownish green colour, which indicate well prepared silage when compared to the standard colour of good silage. The pH range of the products showed that they were well preserved. Mixture of cassava tops and guinea grass silage had average effect on the structural carbohydrate i.e. NDF, ADF, lignin and HCN with the highest CP and all the minerals compared to sole cassava leaf top and sole guinea grass silage. Further studies on different ratios of guinea grass and cassava tops mixture with other preservation methods such as sun drying, heating and boiling for reduction in HCN content of cassava tops and leaves and improvement of the nutritive value of silage from cassava by products are needed. Also, role of different additives for improvement of guinea grass and cassava tops silage and the use of other forage grasses needs further studies.

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