ORGANIC ACIDS AND ANTINUTRITIONAL CONTENTS OF CABBAGE LEAVES WASTE AND PINEAPPLE PEELS SILAGE FED TO WEST AFRICAN DWARF (WAD) GOATS

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ABSTRACT
In Sub-Saharan Africa, the long dry season periods are usually characterized by feed scarcity with a concomitant negative impact on livestock. Ensiling vegetables with fruit trimmings and peels often regarded as waste can be explored as alternative feedstuff, particularly in the off-season. This study was conducted to assess the potential of cabbage leaves waste (CLW) ensiled with pineapple peels (PP) as feed for WAD goats. Diets consisted of the following: T1: 100% Cabbage leaves waste (CLW); T2: 90% CLW + 10% Pineapple peels (PP); T3: 80% CLW + 20% PP; T4: 70% CLW + 30% PP; T5: 60% CLW and 40% PP. The chemical composition, anti-nutrients, and organic acid contents of diets were determined. Results showed that antinutrients in diets were significantly (P<0.05) affected. Flavonoids, oxalate, phytate, and tannin values increased with increasing levels of PP in silage diets. The highest values (399.67mg/100g) were obtained for Saponin in T1 While significantly (P<0.05) lowest saponin values (358.64mg/100g) were obtained in T2. Acetic acid (mmole/100ml) ranged from 7.40 (T2) – 11.53 (T1). Lactic acid and propionic acid values for T1 and T5 were similar but higher than the values reported for T2. It is concluded that increasing levels of pineapple peels in cabbage leaves waste silage improved the organic acid contents while antinutrients remained within acceptable levels.

Keywords*: Cabbage leave waste (CLW), pineapple peels (PP), anti-nutrients, organic acids, West African Dwarf (WAD) goat*

INTRODUCTION

The adequate feeding of ruminants during the dry season is still a challenge in Nigeria (Omotosho *et al.,* 2018). During the critical off-season, ruminant animals lose weight but gain it back in the rainy season. The on-and-off growth pattern is inimical to a successful livestock production system. Hence, an adequate all-year-round supply of nutritious and quality feed in the livestock industries should be ensured to improve the limited animal protein intake suffered in most developing countries of the world, Nigeria inclusive (Odeyinka, 2014).

According to Pignata *et al.* (2017), the processing of fruits and vegetables both on local and commercial scales generates enough quantity of residues that can be utilized as feed for ruminant livestock most especially during off-season which will serve the purpose of reducing the cost of feeding and as well alleviate the environmental pollution that always result from waste fruit and vegetables disposal. The feeding resources for the ruminant livestock which constituted forages and other agricultural byproducts are highly perishable, therefore, the adoption of some conservation methods such as silage making remains one of the viable methods to ensure their supply and availability for the off-season period. Commercial silage additives like molasses are difficult to access by farmers in sub-Saharan Africa due to their prices and availability (Odedire and Abegunde, 2014). Therefore, some agro-industrial byproducts such as pineapple peels which are high in water soluble carbohydrate (WSC) can be used as a substitute for some of the commonly used commercial silage additives like molasses. Although cabbage vegetable and pineapple peels contain some secondary metabolites, compounds that can be toxic to animals and hinder their growth and productivity when fed in large quantities (Taljaard, 1993), it has been demonstrated that ruminal microorganisms can detoxify these compounds when animals are gradually introduced to feeding on cabbage (Duncan *et al.,* 1992). Therefore, the objective of this study is to evaluate the effect of ensiling cabbage leaves waste with varying levels of pineapple peels on some anti-nutritional factors and organic acid contents of silage diets.

MATERIALS AND METHODS

Cabbage Leaves and pineapple peels were collected from different grocery and vegetable stores in Ile-Ife and its environs. All the cabbage leaves collected were chopped and air-dried for 3-4 days. Silage diets which consisted of cabbage leaves waste with pineapple peels included at 0, 10, 20, 30 and 40% as CL: PP mixtures and designated as T1, T2, T3, T4, and T5 respectively were packed, compacted to remove as much air as possible, sealed in thick polythene bags and placed in large drums with large stones placed on them for weight so as to completely remove oxygen for proper anaerobic fermentation. The mixture was ensiled for twenty-eight (28) days after which they were opened and fed to goats based on 4% of their body weight. Silage constituted 60% of the total diet and compounded concentrate diet the remaining 40%. The organic acid compositions of the sample extracts were analyzed following the modified standard test methods of Anthony *et al.* (1986). Sub-sampled silage materials were oven-dried at 70^{o}C to constant weight and crushed using the laboratory milling machine with the maker name of Janke and Kunkel (IKA Labortechik). The crushed samples were weighed and kept in a deep freezer at a temperature of less than 4^{o}C until analysis. Five grams of the sample was weighed and transferred to the extracting bottle that was cocked with TFE-fluorocarbon. 10 ml of the redistilled ether was added for the extraction and vortexed. The mixture was centrifuged to break the emulsion. The extraction was repeated two more times with fresh solvent and the filtrate was combined. The filtrate and its container were kept in the ice to avoid evaporation of the ether. One microlitre was injected into the injection port of the gas chromatography for the analysis of such organic acids as lactic, acetic, butyric, propionic, and valeric. Quantitative determination of tannins, saponins, oxalates, and flavonoids was carried out in triplicates, Saponin and phytate were analyzed using methods of AOAC (2000). All data collected were subjected to a one-way analysis of variance using the General Linear Model (GLM) Procedures of SAS (2001) while differences between means were separated using the Duncan's Multiple Range Test of the same package.

RESULTS AND DISCUSSION

Table 1 shows the chemical composition of the experimental diets. The dry matter (%) was higher in all the silage diets compared to the individual plant constituents (CL: 12.6; PP: 16.47), but significantly ($p<0.05$) lower with the increasing inclusion level of the Pineapple peel as a result of its high moisture content. The crude protein of the silage diets significantly ($p<0.05$) decreased with the inclusion levels of pineapple peels due to the higher crude protein content of cabbage (23.98%) relative to pineapple peels (7.29%), this agrees with the findings of Rezende *et al.* (2015) when

Table1. Chemical Composition of Silage Diets

PARAMETERS (%)	T1	T2	T3	T4	T5	SEM	PROB
Dry matter	32.30^{a}	32.70^{a}	32.75^{a}	28.00^{b}	28.50^{b}	0.63	<0.0001
Crude Protein	23.29^{a}	20.13^{b}	18.23^{c}	17.93^{cd}	16.48^{d}	0.65	<0.0001
Crude Fibre	10.42^{b}	10.28^{b}	10.38^{b}	10.35^{b}	12.74^{a}	0.28	0.0005
Ether Extract	1.45^{d}	2.58^{c}	2.90^{c}	3.26^{b}	4.57^{a}	0.28	<0.0001
Ash	10.86^{bc}	10.48^{c}	11.17^{b}	10.70^{bc}	12.10^{a}	0.17	0.0019
Nitrogen free Extract	53.97^{b}	56.53^{ab}	57.32^{a}	57.75^{a}	54.10^{b}	0.54	0.0308
Fibre Fraction							
Neutral detergent fibre	18.67^{d}	23.14^{c}	24.59^{b}	22.46^{c}	31.39^{a}	1.12	<0.0001
Acid detergent fibre	7.82^{d}	9.84^{c}	15.98^{b}	8.13^{d}	17.78^{a}	1.11	<0.0001
Acid detergent lignin	1.82^{bc}	1.83^{bc}	2.30^{b}	1.29^{c}	3.17^{a}	0.18	<0.0001

$^{a, b, c, d}$: Means within row with the different superscript are significantly different ($P<0.05$). SEM: Standard error means; PROB: Probability. CL: Cabbage leaves; PP: Pineapple peels, T1: 100% CL; T2: 90% CL + 10% PP; T3: 80% CL + 20% PP; T4: 70% CL + 30% PP; T5: 60% CL and 40% PP

wasted cabbage was ensiled with different levels of ground corn and silage inoculants. However, the CP content meets the minimum protein requirement for ruminant livestock which is 8g/100 g DM. The CP ranges for diets were sufficiently high to warrant the utilization of the plant as a feed resource for ruminant animals.

Table 2: Anti-nutritional factors of silage diets

(mg/100g)	T1	T2	T3	T4	T5	SEM	PROB
Saponins	399.67[a]	358.64[d]	366.67[c]	379.63[c]	390.32[b]	4.02	<0.0001
Flavonoids	409.00[d]	418.64[c]	424.67[b]	437.96[a]	440.32[a]	3.16	<0.0001
Oxalates	169.00[e]	184.67[c]	181.67[d]	189.96[b]	198.54[a]	2.60	<0.0001
Phytates	192.67[e]	209.97[c]	199.33[d]	215.63[b]	221.32[a]	2.82	<0.0001
Tannins	31.67[e]	45.64[c]	39.00[d]	55.29[b]	58.14[a]	2.66	<0.0001

[a, b, c, d]: Means within row with the different superscript are significantly different (P<0.05). SEM: Standard error mean; PROB: Probability. CL: Cabbage leave; PP: Pineapple peel, T1: 100% Cabbage leaves; T2: 90% Cabbage leaves + 10% Pineapple peels; T3: 80% Cabbage leaves + 20% Pineapple peels; T4: 70% Cabbage leaves + 30% Pineapple peels, T5: 60% Cabbage leaves and 40% Pineapple peels.

The quantitative analysis of the anti-nutritional factors (ANFs) of the experimental diets is shown in Table 2 above. The result obtained for anti-nutrients showed that all the ANFs except Saponin increased with the inclusion levels of Pineapple peels, this may be due to the contributions from the pineapple peels. The values (192.67-221.32 and 31.67-58.14mg/100g) obtained in this study for phytate and tannins respectively were higher than the values (23.83-31.83, 1.0-2.04mg/100g) obtained for fresh green cabbage vegetable as reported by Mohammed and Luka (2013), while oxalate content (169.00 -198.54mg/100g) of all the silage diets used in this study were lower than the value (219.60-231.60mg/100g) obtained for fresh green cabbage by the same author. The reduction in the oxalate content of the ensiled cabbage leaf wastes with pineapple peels may be attributed to the effectiveness of the fermentation process (Soetan and Oyewole, 2009) in reducing deleterious factors like the oxalic acid. The oxalate content obtained from this study was lower than the critical values of 0.8-1.2% DM which could trigger problems of calcium imbalance (Bolenz *et al.,* 1990). According to Frias *et al.* (2016), fermenting cabbage to make Sauerkraut increases its nutritional profile by adding a variety of organic acids that are not typically found in fresh cabbage, such as lactic, acetic, propionic, malic, and succinic acids.

Table 3: Organic acid profile of the silage diets

Parameters/Treatments (mmole/100ml)	T1	T2	T3	T4	T5	SEM	PROB
Acetic acid	11.53[ab]	7.40[c]	9.27[bc]	10.07[bac]	12.43[a]	0.56	0.0117
Propionic acid	11.16[ab]	7.04[c]	8.83[bc]	9.60[bc]	12.54[a]	0.59	0.0071
Butyric acid	10.66[ab]	6.74[c]	8.45[bc]	9.17[abc]	11.43[a]	0.54	0.0172
Valeric acid	10.61[ab]	6.71[c]	8.40[bc]	9.13[abc]	11.56[a]	0.55	0.0148
Lactic acid	14.56[a]	9.21[c]	11.52[bc]	12.66[ab]	13.43[ab]	0.58	0.0091

[a, b, c, d]: Means within each row with different superscripts are significantly different (p< 0.05); T1 = 100% CL; T2 = 90%CL + 10%PP; T3 = 80%CL + 20%PP; T4 = 70%CL + 30%PP; T5 = 60%CL + 40%PP. CL = Cabbage leaves; PP = Pineapple peels; SEM (±): Standard error of mean; PROB: Probability level.

Results from Table 3 show that apart from T1, the organic acid levels increased in other diets with increasing inclusion levels of pineapple peels. Relatively higher values for all the organic acids were observed in both T1 and T5, and the lactic acid value was significantly (P<0.05) higher in T1 than others. This result conflicts with the findings of Cao *et al*. (2011), who worked with fresh vegetable residues including cabbage, and concluded that the fermentation of cabbage without additives leads to low production of lactic acid and that pH reduction was not satisfactory. This may be attributed to the beneficiary effect of the wilting operation of the plant before ensiling, in increasing the water-soluble carbohydrate (WSC) component and as well as reducing the inherent buffering capacity of the plant materials to be ensiled (Mannetje, 2011). In silage production, Lactic acid and acetic acid profiles are

desirable. Generally, in good quality, well-preserved silage, at least 65-70% of the total acid will be lactic acid or 4-7% lactic acid (%DM), <3% acetic acid, <0.1% butyric acid, and <0.5% propionic acid (Ward, 2011). Acetic acid is desirable because it reduces and prevents the growth of mold on silages. The result obtained from this finding showed relatively higher values for lactic acids across all the treatments when compared to other organic acids, followed by acetic acid which was higher across all the treatments than other organic acids (propionic, butyric, and valeric) analyzed. The result obtained in this study showed that the inclusion of pineapple peels helped improve silage quality. Results also revealed that good silage could still be obtained when cabbage alone is ensiled without pineapple leaves as an additive.

CONCLUSION

The nutritional value of the cabbage leaves waste ensiled with pineapple peels was sufficient as a supplement and met the minimum nutrient requirements for growing WAD goats, and all the evaluated anti-nutritional factors were within the tolerable rate for WAD goats.

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