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Assessment of Silage Quality and Acceptability of *Spondias mombin* by West African Dwarf Goats

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Target Audience: Ruminant Nutritionists, Goat Farmers

Abstract

Scarce forages and low digestibility are major challenges of dry season feeding for ruminants in the tropics. This can be overcome by excess forage conservation in times of abundance by ensiling with cheap and locally available materials containing high fermentable carbohydrates as additives. A study was conducted to investigate the potentials of Spondias mombin as a silage material. Leaves of Spondias mombin were ensiled with its fruits at varying inclusion levels: 0% (control, T1); 10% (T2); 20% (T3) and 30% (T4). After 30 days of ensiling, its quality and chemical composition were assessed and the products were fed to West African dwarf (WAD) goats in a cafeteria experiment, to determine its acceptability. The appearance, odour and texture of the silage had acceptable physical attributes with pH values ranging from 4.7 – 5.8. Crude protein was similar (P>0.05) in the S Spondias mombin silages ensiled with fruits while ether extract values were significantly (P< 0.05) improved. Protein values ranged from 12.25 g/100g DM (Treatment 1) to 14.00 g/100g DM (Treatment 4). Anti-nutritional content of the ensiled S. mombin ranged between 3.78 – 6.75 mg/100g, 2.32 -4.09 mg/100g, 37.00 – 69.23 mg/100g and 0.26 – 3.06 g/100g for tannin, total phenols, phytate and flavonoids respectively. Tannin, total phenols and flavonoids of the silage diets increased with increasing levels of Spondias mombin fruits in the silage. Acetic and butyric acid contents (mg/100g) increased significantly (P<0.05) across the treatments, while lactic acid (mg/100g) increased with increasing level of fruit additive. Acceptability of silage improved with increasing Spondias mombin fruit inclusion, with the control diet rejected by goats. It was concluded that Spondias mombin leaves ensiled with its fruits, produced quality and palatable diets for WAD goats without any deleterious effect.

Keywords: cafeteria experiment; digestibility; forage conservation; ruminants

Description of problem

It is becoming increasingly important to devise strategies for ensuring continuous accessibility to quality feedstuff by ruminant animals all year round. One of the problems of ruminant animal production in the tropical humid zone of West Africa is the seasonal variation in the availability and nutritional value of natural grasslands (1) especially during

dry season period. The resultant effect of this is the "on - and - off" (staircase) growth rate pattern exhibited by the animals over time, which negatively affects the overall productivity of the animals (2). This has necessitated concerted efforts on innovative research geared towards cheaper and indigenous feed alternatives that would support the growth performance of ruminant animals during the critical season. Browse in the form of trees and shrubs form an integral part of ruminant production. Feeding of browse has become an essential practice especially in the dry season when herbaceous forages are scarce (3). Some browse species such as *Spondias mombin* are abundant throughout the wet seasons. *Spondias mombin*, also known as yellow mombin or golden apple, is commonly referred to as "Iyeye" in the Yoruba – speaking parts of Nigeria, where the tree serve mainly the purpose of shade provision in village squares and rural communities. The tree produces edible fruits that are long, ovoid and yellow, with a sharp, mildly acidic taste. During the fruiting season, fruits ripen and fall to the ground, forming a carpet of yellow mass undergoing different stages of fermentation. The fallen fruits tend to pose a challenge of environmental pollution when left unattended to. Conservation of forages is a step towards achieving sufficiency and sustainability in ruminant production and one prominent method of conservation in the tropics is the production of silage from such abundant forage or feed resource. Silage making with the use of additives is an important tool for farmers in preservation of surplus feed during the wet season toward ensuring all year round availability of feed (4). Additives are important components of silages used to ensure silage fermentation and their nutritional quality. Brewers dried grains, Palm kernel cake, Wheat offal, sugar cane and cassava by – products have been reported by several researchers as possible additives (1, 5, 6) but the costs of procuring these additives have been of concern, particularly for small scale resource poor farmers who are the main rearers of sheep and goats in the tropics. This study was therefore designed to assess the silage quality, and acceptability of mixtures of leaves and fruits of *Spondias mombin* by West African Dwarf goats.

Materials and Methods

***Silage making*:** Leaves of *Spondias mombin* were harvested from different parts of the matured trees within the premises of Obafemi Awolowo University, Ile-Ife while ripened fruits were hand-picked from the base of the trees. Fruits of *S. mombin* were washed with clean water and the thin epicarp removed to expose the fleshy mesoderm for fermentation. The leaves were chopped into lengths of 2 – 3 cm for ease of compaction, wilted for 9 hours in order to reduce the moisture content, and then mixed with the fruits in graded levels of 0, 10, 20 and 30% (w/w) before ensiling, to form Treatment1 (*S. mombin* leaves ensiled without additives), Treatment2 (90% *S. mombin* leaves + 10% fruit additive), Treatment 3 (80% *S. mombin* leaves + 20% fruit additive) and Treatment4 (70% *S. mombin* leaves + 30% fruit additive). Silage was prepared in 25kg industrial polythene bags in triplicate and packed together in a galvanized metal tank to prevent rodents

'incursion. Ensiling was done for 30 days.

***Determination of silage quality*:** At the end of 30 days, the fermentation was terminated by opening the silage bags for volatile fatty acid determination. Quality characteristics assessed include colour, aroma and texture using the method of (7). Silage pH was determined as described by (8). Colour assessment was carried out through visual assessment with the aid of a colour chart. The aroma of the silage was assessed by 6 different people and categorized as pleasant, fruity and pungent. Sub-samples from the treatments and at different depths were taken and mixed together for dry matter determination by oven drying at 65^0C until a constant weight was achieved. The samples were later milled and stored in triplicates in cellophane bags until needed for chemical analysis.

***Chemical Analysis*:**

Crude protein, crude fibre, ether extract and ash of the silages were determined according to the methods of (9). Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Acid Detergent Lignin (ADL) were determined using the procedure of Van Soest *et al*. (1991). Anti-nutrients were determined using standard phytochemical analytical methods (10, 11). Organic acid determination of the sample extraction and analyses were carried out using the modified standard test methods of (12). All data were subjected to a one way analysis of variance (ANOVA) of SAS (13) in a completely randomized design and treatment means, where significant, were separated using Duncan's Multiple Range Tests of the same package.

***Acceptability trial*:**

Acceptability of the silage diets by WAD goats was done using 12 goats in a cafeteria experiment that lasted 7 days after initial 5 days of feed adaptation. About 4kg of each diet was introduced daily on cafeteria basis in ten different concrete feeding troughs according to the methods of (2) giving each animal free access to each of the diet in the trough. The positioning of the feeds was changed daily to prevent bias by the animals in recognizing part of the pen for a particular diet. The amount of feed consumed was monitored for six hours per day after which dried cassava peels was served to the animals. Feed preference was determined from the coefficient of preference (CoP) value (8 14). A silage was adjudged to be relatively preferred if the CoP value is greater than unity{1}.

$$\text{CoP} = \frac{\text{Intake of individual feed offered}}{\text{Mean intake of all the feed offered}}$$

Results and Discussion

Physical characteristics, pH and proximate composition of silage diets

Table 1 shows the physical properties and pH of the ensiled *S. mombin* leaves and fruits. Leaves ensiled with varying levels of fruits (Treatments 2, 3 and 4) had similar silage appearance. They all presented the olive green colour indicative of good silage. Silage without fruit additive (Treatment 1) showed some black/brown patches suggesting mouldy growths as a result of poor fermentation. These were similar to the reports of (15) who observed that Elephant grass silage ensiled with higher levels of cassava peel as additive

Table 1: Physical characteristics and pH of *Spondias mombin* leaves and fruit silage

Parameter	Treatment 1	Treatment 2	Treatment 3	Treatment 4
Appearance	Yellowish green with mouldy patches	Yellowish green	Yellowish green	Light yellowish green
Odour	Not pleasant	Slightly Pleasant with fruity smell	Pleasant with fruity smell	Pleasant with fruity smell
Texture	Firm, moist	Firm, wet	Firm, wet	Firm, wet
pH	5.8	5.0	4.9	4.7

Treatment 1: 100% Spondias mombin leaves without additive (fruits); Treatment 2 10% fruits with 90% leaves; Treatment 3: 20% fruits (additive) with 80% leaves; Treatment 4: 30% fruits (additive) with 70% leaves.

had a lighter green colour than those with little or no cassava peel. The green colour obtained in this study showed that the silages had been preserved well since they were close to their original colour. Good preservation is predicated upon adequate lactate fermentation which has been found acceptable to most farm animals (16). All the silage treatments, except those without fruits, had a pleasant and fruity smell which increased with increasing level of *S. mombin* fruits in the mixture. The pH of the silages ranged from 4.7 to 5.8. The pH values for Treatments 1 and 2 were higher than the acceptable range for good silage in the tropics (17) but Meneses *et al*. (18) reported pH values of 4.5 – 5.5 as adequate for silages in the tropics. The lower the silage pH, the better the fermentation. (19). The pH values of the ensiled mixtures reduced with increasing level of fruit inclusion, showing that addition of *S. mombin* fruit as additive was effective in improving fermentation characteristics of the leaf silage. This agrees with the results of (15) who reported a reduction in pH with increasing levels of cassava peels (additives) in the silage.

Proximate composition of the silage diets are presented in Table 2. Dry matter content of the silages ranged between 23.47% (Treatment 1) and 26.00% (Treatment 4). This is lower than the range of values of 62.20 – 91.00% reported by (1) for silage from pineapple fruit wastes and cassava peels, but similar to values of 21.95 – 38.92 reported by (8) for vetiver grass harvested at different weeks and ensiled with or without cassava peels. Dreihuis (20) had recommended a dry matter range of 40-45%. He also reported that when product is too dry, fungi may develop. This may have been the case

Table 2: Proximate composition (g/100g DM) of *S. mombin* leaves and fruits

	S. mombin leaves	*S. mombin* fruits
Moisture	16.15 ± 0.53	80.3 ± 0.53
Crude Fibre	11.40 ± 0.88	4.44 ± 0.08
Crude Protein	11.70 ± 0.70	2.30 ± 0.05
Ash	0.10 ± 0.004	1.10 ± 0.02
Ether Extract	3.82 ± 0.33	4.00 ± 0.04

**Values are mean ± standard deviation of triplicate determinations*

with the ensiled *S. mombin* leaves without fruits as some black and brown fungi spots were noticed on them. There was an increase in the dry matter values observed in Treatment 4 when compared to others. This is not consistent with an earlier report of dry matter loss in silage (8). In contrast to existing reports (7, 21, 22), crude protein (CP) values of silages increased with increasing levels of fruit additive, thus indicating the possibility of the fruits being able to improve the protein content of silages. The CP values were above the 7% (23) and 10 – 12% (24) recommended for ruminants.

Anti- nutritional components

Table 3 shows the anti-nutrients component of the Treatment diets which revealed that tannin, total phenols, phytate and flavonoids ranged between 3.78 – 6.75 mg/100g, 2.32 - 4.09 mg/100g, 37.00 – 69.23 mg/100g and 0.26 – 3.06 g/100g respectively. The values for tannin in this study were higher than the value of 0.17mg/100g reported for ensiled *Tithonia diversifolia* with sugarcane molasses (25). Results further shows that tannin, total phenols and flavonoids increased with increasing level of fruits inclusion in the silages. This observation indicates the preponderance of tannin in the fruits of *Spondias mombin*, hence its increase as the inclusion levels of fruits in the silage increased. Fasuyi *et al.* (25) reported a decrease in the major anti-nutrient contents (tannin, phenol, oxalate and flavonoids) of ensiled *Tithonia diversifolia* leaves using sugarcane molasses as fermentable carbohydrate. Results from this study did not agree with those of (26, 27) who reported a significant reduction of about 86% in the oxalate content of the raw leaves of Taro (*Colocasia esculenta* (var.) Schott). Flavonoid contents were observed to be higher (2.42-3.06 g/100g) in *S. mombin* silage than those (0.70-0.76 mg/100g) reported for Tithonia leaves ensiled with sugarcane molasses (25) Spondias plant leaves and fruits have been reported to contain flavonoids, which are phenolic compounds that serve as flavouring ingredients of spices and vegetables (28). This might help to improve palatability across the treatments as was

Table 3: Proximate composition (g/100g DM) of *S. mombin* leaves and fruits silages

Parameter/Treatment	T1	T2	T3	T4	SEM	P value
Dry Matter	23.47	24.43	24.50	26.00	0.13	0.00
Crude Fibre	20.70^{a}	17.43^{bc}	16.17^{c}	18.63^{b}	1.31	0.17
Crude Protein	12.25^{b}	13.27^{a}	13.71^{a}	14.00^{a}	0.99	0.64
Ash	9.51	7.97	8.30	9.70	0.51	0.10
Ether Extract	5.25^{c}	7.19^{b}	9.35^{a}	7.44^{b}	0.41	0.00
NFE	31.15^{a}	29.70^{a}	28.92^{ab}	24.51^{b}	1.51	0.05
NDF	43.93^{a}	26.45^{b}	37.40^{a}	37.40^{a}	2.80	0.02
ADF	28.68^{a}	20.08^{c}	21.66^{c}	26.37^{b}	2.14	0.05
Lignin	12.53	11.73	12.81	10.11	2.78	0.91
Hemicellulose	14.25^{ab}	9.38^{b}	15.77^{a}	11.03^{ab}	1.45	0.05
Cellulose	16.16^{a}	7.68^{b}	8.82^{b}	16.26^{a}	2.07	0.03

$^{a, b, c}$:Means within row with the same superscript are not significantly different ($P < 0.05$).

Note that; T_1: 100% *Spondias mombin* leaves without additive (fruits); T_2: 10% fruits with 90% leaves; T_3: 20% fruits (additive) with 80% leaves; T_4: 30% fruits (additive) with 70% leaves

observed in the acceptability trial for diets by WAD goats. The anti-herpes, antioxidant and anti-aging properties (29) of *S. mombin* leaves are linked with its content of flavonoids and other phenolic derivatives (30).

Volatile fatty acids profile

Table 4 shows the volatile fatty acids profile of the silages. Acetic and butyric acids increased with increase in fruits in the silages. In practice, parameters such as silage pH, short chain fatty acids and ammonia content are valuable indicators of silage quality (31), though the increase in silage content of butyric acid and acetic acid were not calculated in terms of the percentage volatile fatty acids, the values for the butyric acid were high. Mc Donald *et al.* (22) reported that silages containing more than 10% butyric acid of the total volatile fatty acids are poorly preserved. The practical relevance of this lies in the implication that feed intake might be reduced due to low palatability (32). The concomitant production of lactic acid and acetic acid is considered positive because acetic acid increases the aerobic stability of the silage due to the inhibition of spoilage organisms (33).

Coefficient of preference (CoP)

Table 6 presents the forage acceptability of *S. mombin* leaves and fruit silage by WAD goats. The forage preference revealed that the CoP values of Treatments 1 and 2 {0.93 and 0.37}respectively were unacceptable to goats offered the silage diets. When CoP is equal or greater than 1, the diet is considered to be acceptable and when CoP is less than 1, the diet is assumed to be unacceptable to livestock (34). Treatments 3 {1.25}and 4 {1.44} were well accepted by the WAD goats. Olorunnisomo and Fayomi (35) had earlier noted that CoP may not be a

Table 4: Anti-nutritional factors of *S. mombin* leaves and fruit silages

Parameters / Treatments	T_1	T_2	T_3	T_4	SEM	P Value
Tanin (mg/100g)	3.78^{d}	4.22^{c}	5.60^{b}	6.75^{a}	$6.5x10^{-4}$	$<1.0x10^{-4}$
Total Phenol (mg/100g)	2.32^{d}	2.53^{c}	3.95^{b}	4.09^{a}	$1.0x10^{-2}$	$<1.0x10^{-4}$
Alkaloids (g/100g)	3.25^{b}	3.35^{a}	2.44^{d}	2.50^{c}	$1.0x10^{-2}$	$<1.0x10^{-4}$
Saponin (g/100g	2.48^{c}	2.59^{b}	1.51^{d}	3.05^{a}	$1.2x10^{-2}$	$<1.0x10^{-4}$
Phytate (mg/100g)	69.23^{a}	41.08^{b}	37.00^{d}	39.43^{c}	$6.0x10^{-2}$	$<1.0x10^{-4}$
Oxalate (mg/100g)	0.58^{c}	1.19^{b}	1.31^{a}	1.33^{a}	$2.0x10^{-2}$	$<1.0x10^{-4}$
Flavonoids (g/100g)	0.26^{d}	2.42^{c}	2.53^{b}	3.06^{a}	$1.0x10^{-2}$	$<1.0x10^{-4}$
Phytin Phosphorus (mg/100g)	19.50^{a}	11.58^{b}	11.11^{c}	10.43^{d}	$2.0x10^{-2}$	$<1.0x10^{-4}$

$^{a, b, c, d}$:Means within row with the same superscript are not significantly different (P <0.05).

Note that; T_1: 100% *Spondias mombin* leaves without additive (fruits); T_2: 10% fruits with 90% leaves; T_3: 20% fruits (additive) with 80% leaves; T_4: 30% fruits (additive) with 70% leaves.

Table 5: Volatile fatty acid profile of *S. mombin* leaves and fruit silages

VFA(mg /100g)	T_1	T_2	T_3	T_4	SEM	P-value
Acetic acid	2071.46^{d}	2784.53^{c}	3321.08^{b}	3945.62^{a}	0.99	<0.0001
Propionic acid	1308.86^{b}	1202.54^{d}	1450.46^{a}	1278.46^{c}	0.65	<0.0001
n-butyric acid	168.28^{d}	264.42^{c}	285.08^{b}	325.92^{a}	0.49	<0.0001
Lactic acid	1907.26^{d}	2107.68^{c}	2455.78^{b}	2649.58^{a}	0.50	<0.0001

$^{a, b, c, d}$:Means within row with the same superscript are not significantly different (P <0.05).

Note that; T_1: 100% *Spondias mombin* leaves without additive (fruits); T_2: 10% fruits with 90% leaves; T_3: 20% fruits (additive) with 80% leaves; T_4: 30% fruits (additive) with 70% leaves.

Table 6: Dry Matter Intake (DMI; Kg DM) and coefficient of preference (CoP) of *S. mombin* leaves and fruit silage by West African Dwarf (WAD) goats

Treatments	DMI (Kg DM)	CoP	% Preference	Preference ranking
T1	0.094	0.93	23.33	3rd
T2	0.037	0.37	9.18	4th
T3	0.130	1.25	32.26	2nd
T4	0.142	1.44	35.26	1st

DMI=Dry Matter Intake, CoP= Coefficient of Preference. *T1: 100% Spondias mombin leaves without additive (fruits); T2 10% fruits with 90% leaves; T3: 20% fruits (additive) with 80% leaves; T4: 30% fruits (additive) with 70% leaves.*

realistic measure of acceptability of diets by ruminants since it does not take into consideration the previous experience of the animals, or the relative importance of changing dietary preference of livestock. Hence, a further calculation of the preference percentage was done. Percent preference appears to be a more realistic index of acceptability since it does not foreclose the possibility of changing dietary preference among livestock (34). In this study, the percent preference of goats ranged from 9.18 – 35.26% and ranked as: T4>T3>T1>T2. This implies that goats preferred *S. mombin* leaves silage ensiled with 30% fruits most. This may be attributable to the fruity smell and lower pH which may have proffered better fermentation and consequently, better silage qualities on the diets.

Conclusion and Application

1. *Spondias mombin* fruits added to leaves silage improved physical characteristics and protein content of silage up to 30% inclusion level.
2. West African Dwarf Goats preferred *Spondias mombin* leaves silage ensiled with 20 – 30% fruits.

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