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Potentials of Signal Grass Ensiled with Brewer's Dried Grain and Cassava Peel as Feed for Ruminant Animals during the Dry Season

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Abstract Forage scarcity in the dry season is a challenge for ruminant production in the tropics. The utilization of Brachiaria decumbens, particularly as silage can bridge this gap. The potentials of Brachiaria decumbens ensiled with varying levels of brewers' dried grain (BDG) and cassava peel as dry season feed for West African dwarf (WAD) goats were assessed. Different mixtures of Brachiaria decumbens, BDG and cassava peel were ensiled as follow: T1:100% B. decumbens, T2:60% B. decumbens + 40%BDG + 0% cassava peel; T3:60% B. decumbens+ 30% BDG+10% cassava peel, T4: 60% B. decumbens+ 20% BDG+20% cassava peel, T5:60% B. decumbens + 10% BDG+ 30% cassava peel, T6:60% B. decumbens+ 40% cassava peel. The silages were offered to twelve West African Dwarf Goat to assess the preference of the silage in a cafeteria experiment. Appearance, odour, colour and texture had acceptable physical attributes with pH value ranging from 4.3- 4.7. Chemical composition of the silage diet showed 24.60-43.90% Dry matter (DM),15.80-17.66% Crude protein (CP), 15.80-17.66% Ash, 3.37-3.68% Ether extract (EE), 71.45-73.85% Neutral detergent fiber (NDF), 50.65-53.30% Acid detergent fiber (ADF), 23.30-24.60% Acid detergent lignin (ADL), 20.45 -23.20% Hemicellulose, 27.35 -29.05% Cellulose, 0.24- 0.26% Calcium. DM, CP and hemicellulose were significantly affected. The coefficient of preference and percentage of preference shows that treatment 1 which is 100% Brachiaria decumbens was more preferred by goat than other silage mixture. The order of preference was T1>T2>T6>T3>T4>T5. The result showed that Brachiaria decumbens ensiled with BDG and cassava can be preserved as feed for ruminant in time of fed scarcity.

Keywords: *Brachiaria decumbens, WAD goats, Cassava peel, Brewers Dried grain, silage*

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1. Introduction

Pasture availability all year round is not always guaranteed in the tropics especially in Nigeria because of the length of the dry season. This shortage of good quality forage needed to cater for the feeding needs of the animals especially during the dry season has been a perennial problem which affects the general ruminant production at large; this is unlike the rainy season when there is abundance of grasses and pasture of good nutritive value. During this period available feed stuff become fibrous and have low digestibility leading to poor livestock production [1,2].

The preservation of excess pasture during surplus in the form of silage is indispensable and this allows mitigating the feed deficit that could be encounter during the dry season. The quality of the silage is however dependent on the quality of the crop at ensiling type of fermentation, rate of pH decrease, moisture content of the crop and anaerobic conditions [3]. Silage, making in the tropics is paramount if there will be all year round availability of forages for livestock. Fodder conservation is promoted with the main objective of ensuring feed availability during periods of feed limitation [4].

Brachiaria decumbens is an important forage grass in the tropics because it has exceptional adaptation to acid soils, vigorous growth, ease of establishment and good forage value throughout the year [5]. It is a tropical and sub-tropical grass widely cultivated for forage. *Brachiaria decumbens* is high in production of dry matter when planted in areas with low rainfall [6]. It is high-yielding and forms low leafy stands that do well on infertile soils. It is palatable to all classes of livestock and withstands heavy grazing [7]. It can be grazed, cut to be fed fresh or to be made into hay or silage. Quality of this grass can improve with addition of a readily fermentable carbohydrate like cassava peel which is cheap and available in large quantities in Nigeria. Cassava peel produced in large qualities, from the processing of cassava for human, industrial and export purposes. Cassava peel is found to be suitable to use as an energy sources feed stuff in the fermentation of silage, however, it is low in protein and high in ash percentage it must be use with high protein sources such as BDG and urea [8].

Brewer's grains are a highly variable by-product whose composition and nutritional value depend on the grain used, on the industrial process (temperature, fermentation, etc.) and on the method of preservation. Brewers grains are sold wet or dried, and can be ensiled [9]. Brewers grains is a less expensive protein rich concentrate with high digestibility, can meet a significant portion of supplemental protein requirement, energy and fibre needed as bulk in diets of ruminants [10]. Brewer's dried grain is intermediate in protein, suitable for inclusion in dairy, beef cattle, sheep and goat up to 25 - 30 % [11].

Grass effectively managed can be strategically exploited to ameliorate forage scarcity in the off season. The amounts of grass forage given and eaten depend on several factors based on plant- animal relationship that would also determine whether farmer's objective would be realized. Preference of herbage is a result of available choice, physical and chemical characteristic of the plant materials where measuring of voluntary intake through cafeteria trials. Feed choice intake and acceptability study is a quick assessment of physical quality of feed. Coefficient of preference (COP) is a direct measure of acceptability and nutritional capacity of feedstuff or forage. In recent times cafeteria techniques have been used to access the acceptability of some forage [12,13]. The feed intake or the palatability of the forage is regulated by many factors harvesting, physical and metabolic feedback and secondary metabolites. Preservation method also affect these factors especially in reducing the secondary compound or anti nutritional substances [14]. The objectives of the study are to access the potentials of *B. decumbens* ensiled with varying level of cassava peel and brewer's dry grain as ruminant feed during the dry season.

2. Materials and Methods

2.1. Experimental Site

The research was carried out at the Sheep and Goat Unit of the Teaching and Research Farm of Ladoke Akintola University of Technology (LAUTECH) Ogbomosho, is located in the derived savanna zone of Nigeria.

2.2. Silage Preparation and Ensiling Process

Brachiaria decumbens was harvested from already existing pasture plot at LAUTECH Teaching and Research farm, Ogbomosho, Oyo State. The cassava peel was collected from a reputable garri processing unit around the university. The Brewer's dried grain (BDG) was collected from a reputable feed mill in Ogbomosho, Nigeria.

Silage was prepared in mini silos (60L plastic drums). Fresh *Brachiaria decumbens* was harvested from the field and wilted to 30% dry matter in order to reduce the moisture content after which was chopped to 2-3 long length for ease of compaction and combination for silage. The cassava peel was crushed using the crusher to reduce the particle size. The chopped grasses and the cassava peel with BDG was mixed thoroughly to attain an even mixture. Six experimental treatments were prepared as follow;

Treatment 1: 100% *Brachiaria decumbens*

Treatment 2: 60% *Brachiaria decumbens* + 40% BDG + 0% Cassava Peel

Treatment 3: 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel

Treatment 4: 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel

Treatment 5: 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel

Treatment 6: 60% *Brachiaria decumbens* + 0% BDG + 40% Cassava Peel

Each mixture was packed in the mini silos (lined with 20mm thick nylon sheets) and compressed with heavy stones and sand bags to eliminate air and immediately, the plastic cover was placed, sealed and allowed to ferment for 56 days.

2.3. Silage Quality and Assessment

After 56 days the fermentation was terminated and silage was opened for silage quality. The assessed quality and characteristic were color, aroma, texture, pH and temperature according to Babayemi and Igbekoyi [15]. Immediately the silage was opened, a laboratory thermometer was inserted to determine the temperature. The pH of the silage was determined pH meter. Color assessment was ascertained using visual observation within the aid of color charts. The aroma of the silage was relatively assessed as to whether nice pleasant, fruity or pungent. Sub sample from different point and depth were taken and mixed together for dry mater determination by oven drying at 65°C until a constant weight is achieved. The sample were later milled and stored in an air tight container ready for chemical analysis.

2.4. Microbial Analysis

After 56 days of fermentation the silage was opened, 5g of each samples were taken by a gloved hand into a sterilized bottle and freeze prior to analysis. Exactly 1g of the silage was mixed with 9ml of sterilized water; the mixture was used for serial dilution to 10^3. The dilution was placed on the following media; De-man-Rogosa-Sharpe Agar(MRS) to detect lactic acid bacteria(LAB), Nutrient agar to detect aerobic bacteria, Yeast extract agar(YEA) for yeast and yeast like fungi, Potato Dextrose Agar(PDA) to detect mould and Mac conkey Agar(MAC) to detect entrerobacteria. C.F.U= N × wt × D, Where; C.F.U=Colony Forming Unit (g/ml); N=Number of Colony, Wt. =Weight of Sample (g); D=Dilution factor (ml).

2.5. Experimental Animals and Management

Eighteen (18) West African Dwarf goats between the ages 8-10 month were sourced from scattered markets around Ogbomosho. The goats were confined for one-month adaptation they were allowed unrestricted access to clean drinkable water, mineral lick, and cassava peels and beans shaft. The floor of the pen was covered with wood shavings for the absorption of urine and feaces.

2.6. Preferential Study

Twelve (12) West African Dwarf goats were used for the Preferential Study. 1.5kg of each diet in three replicate were introduced on cafeteria basis to the animals in 12 different feeding troughs, thus each animal has free access to each of the diet in the trough. The positioning of the feeds was changed daily to prevent bias by the animals taking a particular type of feeds. The amount consumed was monitored for 4 hours per day and the quantity consumed was recorded. After then the animals were released to go for grazing. Feed preference was determined from the coefficient of preference (CoP) value calculated from the ratio between the intake of each individual feed sample divided by the average intake of feed samples [12,16] on the basis, a feed was taken to be relatively preferred if the CoP value is greater than unity.

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

2.7. Chemical Analysis

Dried samples of the experimental diets were analyzed for crude protein, dry matter, ether extract, crude fiber content as described [17], neutral detergent fiber (NDF), Acid Detergent fiber (ADF), Acid detergent lignin (ADL) were determined according to the method of Van Soest e*t al.*, [18].

2.8. Statistical Analysis

All collected data were processed by one-way analysis of variance using statistical analyst software [19] package. Significantly ($P<0.05$) different means among variables were separated using New Duncans Multiple Range Test as contained in the same package.

3. Result and Discussion

The silage quality of Brachiaria *decumbens* ensiled with cassava peel and brewers dried grain are shown in Table 1. The color of silage ranges from light yellow in sole *Brachiaria decumbens* to light brown in the silage as the quantity of brewers dried grain and cassava peel varied. Differences were observed in smell of the silage as silage from treatment 2 (60% *Brachiaria decumbens* + 40% brewers dried grain + 0% cassava peel) has fairly pleasant smell, as the cassava peel increase (Treatment 3, 4, 5) the smell of the silage were pleasant and treatment 6 with the highest level of cassava peel with no brewers dried grain had very pleasant smell.

The texture of the present silage was firm with exception of silage in treatment 1 (100% *Brachiaria decumbens*) and treatment 6 (60% *Brachiaria decumbens* + 40% cassava peel) that were moderately firm.

The pH of the silage falls within the range of 4.2-5.5 the highest pH was observed in sole *Brachiaria decumbens* treatment 1 while the least value was observed in treatment 6 (60% *Brachiaria decumbens* + 40% cassava peel+ 0% brewers dried grain).

Temperature ranges from 28°C - 30°C treatment 1 (100% *Brachiaria decumbens*) has the lowest while treatment 6 (60% *Brachiaria decumbens* + 40% cassava peel) has the highest.

3.1. Chemical Composition of *Brachiaria decumbens* Ensiled with Brewer's Dried Grain and Cassava Peel

The chemical composition of *Brachairia decumbens* ensiled with cassava peel and brewers dried grain are presented in Table 2. The Dry matter (DM), crude protein (CP) and hemicellulose content of the silage differ significantly ($P < 0.05$) while the other did not differ significantly. Dry matter content of the silage ranges from 24.60-43.90% the lowest is treatment 1 and the highest is treatment 2. The CP ranged from from 9.80-18.90% which is very low in treatment 1 and high in treatment 2. Ash content recorded 15.80% in treatment 1 and the highest value (17.66%) in treatment 6. Ether extract (3.37-3.68%) showed treatment 6 had the lowest while treatment 2 has the highest EE content. As for the fibre components, the NDF varied between 71.45% for silage in treatment 2 (60% Brachiaria decumbens + 40% brewers dried grain + 0% cassava peel) to 73.85% for silage in treatment 6 (60% *Brachiaria decumbens* + 40% cassava peel + 0% brewers dried grain) while the ADF was in the range of 50.65% for silage in treatment 6(60% *Brachiaria decumbens* + 40% cassava peel + 0% brewers dried grain) to 53.00 for silage in treatment 1(100% *Brachiaria decumbens).* The ADL range from 23.30-24.60%, treatment 6 (60% *Brachiaria decumbens* + 40% cassava peel + 0% brewers dried grain) has the lowest and treatment 3 (60% *Brachiaria decumbens* 10%cassava peel 30% brewers dried grain) with the highest. The lowest to Highest Hemicellulose recorded ranged from 20.45-23.20% in T6 and T2 respectively. Cellulose content ranged from 27.35-29.05% in T6 and T1 respectively.

Table 1. Physical characteristics, Temperature and pH of Signal grass (*Brachiaria decumbens)* ensiled with Cassava peel and Brewers dried grain

TREATMENT	COLOUR	SMELL	TEXTURE	pH	TEMPERATURE
T1	OLIVE GREEN	ALMOST PLEASANT	MODERATELY FIRM	5.5	28ºC
T2	BROWN	PLEASANT	FIRM	4.7	29ºC
T3	BROWN	PLEASANT	FIRM	4.7	29ºC
T4	DARK	PLEASANT	FIRM	4.6	29ºC
T5	DARK BROWN	PLEASANT	FIRM	4.5	28.5ºC
T6	DEEP BROWN	VERY PLEASANT	MODERATELY FIRM	4.2	30ºC

T1= 100% *Brachiaria decumbens;* T2= 60% *Brachiaria decumbens* + 40% BDG + 0% Cassava peel
T3= 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel
T5= 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% BDG + 40% Cassava Peel.

Table 2. Chemical composition result of *Brachiaria decumbens* ensiled with brewer's dried grain and cassava peel

Treatment	T1	T2	T3	T4	T5	T6	SEM
Dry matter	24.60^{c}	43.90^{a}	40.50^{a}	35.60^{b}	32.50^{b}	27.90^{c}	1.19
Crude protein	9.80^{c}	18.90^{a}	15.06^{ab}	14.18^{b}	13.30^{bc}	11.03^{bc}	1.26
Ash	15.80	16.65	16.50	17.17	15.89	17.66	1.09
Ether extract	3.45	3.68	3.46	3.39	3.61	3.37	0.12
Neutral Detergent Fibre (NDF)	73.80	73.85	73.45	73.08	73.80	71.43	0.72
Acid Detergent Fibre (ADF)	53.00	50.65	52.60	52.00	51.00	52.60	0.70
Acid Detergent Lignin (ADL)	23.95	23.30	24.60	24.05	23.45	24.50	0.61
Hemicelluloses	20.80^{b}	23.20^{a}	20.85^{b}	21.08^{b}	20.45^{b}	21.20^{b}	0.58
Cellulose	29.05	27.35	28.00	27.95	27.55	28.10	0.52
Calcium	0.26	0.24	0.25	0.24	0.26	0.25	0.003
Phosphorus	0.37	0.36	0.36	0.37	0.37	0.37	0.004

$^{a, b, c, d,}$ means with different superscript on the same row are significantly different.
SEM: Standard error of means.
T1= 100% *Brachiaria decumbens;* T2= 60% *Brachiaria decumbens* + 40% BDG + 0% Cassava peel; T3= 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel; T5= 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% BDG + 40% Cassava Peel

The calcium values ranges from 0.24% to 0.26%, with the same values occurring more than once in the column. The phosphorus values is from 0.36% and 0.37%, both of the values repeated itself across the column of treatment 1 to 6 more than once. The ca –p values ranges from 0.65% to 0.69%, with the lowest in T2 and highest in T1.

Table 3 shows the pH, Water Soluble Carbohydrate and Ammonia Content of the experimental silage. The pH value recorded across the experimental silages ranged from 4.4 to 5.5. The Water Soluble Carbohydrate recorded across the experimental silages ranged from 29.26 (T5: 60% *Brachiaria decumbens* + 10% Brewers Dried Grain + 30% Cassava Peel) being the lowest, to 29.66 (T1: 100% *Brachiaria decumbens)* being the highest. There were significant differences between the ammonia content recorded across the experimental silages which ranged from 0.87 (T5= 60% *Brachiaria decumbens* + 10% Brewers Dried Grain + 30% Cassava Peel) being the lowest to 0.97 (T3: 60% *Brachiaria decumbens* + 30% Brewers Dried Grain + 10% Cassava Peel) being the highest.

3.2. Microbial Analysis for *Brachiaria decumbens* Ensiled with Brewer's Dried Grain and Cassava Peel

The microbial analysis for *Brachiaria decumbens* ensiled with cassava peel and brewer's dried grain are presented in Table 4. The total aerobic bacteria value ranges from 6.27log10 cfu/g to 6.88 log10 cfu/g, with the lowest in T2 and highest in T3, there is significant difference. The lactic acid bacteria range from 7.40 log10 cfu/g to 7.76 log10 cfu/g, with the lowest in T4 and highest in T5. The acetic acid bacteria range from 2.72 log10 cfu/g to 3.09 log10 cfu/g; T4 is the lowest and T5 is the highest. Propionic acid bacteria ranges from 1.23log10 cfu/g to 1.83 log10 cfu/g, it is highest in in T5 and lowest in T1. Butyric acid bacteria values ranges from 1.43 log10 cfu/g to 1.85 log10 cfu/g, with T1 being the lowest and T3 the highest.

Table 3. pH, Water soluble carbohydrate and Ammonia of signal grass ensiled with varying levels of cassava peel and brewers dried grain

Parameters	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**
pH	5.5	4.7	4.7	4.6	4.5	4.4	0.213
Water-Soluble Carbohydrates	29.26	29.28	29.48	29.52	29.59	29.66	28.39
Ammonia (NH3)	0.89^{cd}	0.97^{a}	0.93^{ab}	0.92^{bc}	$0.90b^{cd}$	0.87^{cd}	0.014

$^{a, b, c, d,}$ means with different superscript on the same row are significantly different.
SEM**:** Standard error of means
T1= 100% *Brachiaria decumbens;* T2= 60% *Brachiaria decumbens* + 40% BDG + 0% cassava peels
T3= 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel
T5= 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% BDG +40% Cassava Peel.

Table 4. Microbial analysis of *Brachiaria decumbens* ensiled with cassava peel and brewer's dried grain

Parameters (x10^9ml)	**T1**	**T2**	**T3**	**T4**	**T5**	**T6**	**SEM**
TAB	6.83^{ab}	6.27^{b}	6.88^{a}	6.48^{ab}	6.55^{ab}	6.71^{ab}	0.17
LAB	7.64	7.60	7.68	7.40	7.41	7.76	0.19
AAB	2.85	2.84	2.94	2.72	3.09	2.76	0.16
PAB	1.23b	1.65a	1.73a	1.56ab	1.83a	1.56ab	0.10
BAB	1.43b	1.79a	1.85a	1.69a	1.81a	1.66ab	0.08

$^{a, b, c, d, e}$ means with different superscript on the same row are significantly different.
SEM: Standard error of means
T1= 100% *Brachiaria decumbens; T2*= 60% *Brachiaria decumbens* + 40% BDG
T3= 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel
T5= 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% BDG +40% Cassava Peel.

Table 5. Volatile fatty acid analysis of *Brachiaria decumbens* ensiled with cassava peel and brewer's dried grain

PARAMETERS	T1	T2	T3	T4	T5	T6	SEM
Lactic acid	7.64	7.35	7.46	7.60	7.68	7.76	0.19
Acetic acid	2.85	2.65	2.84	2.83	2.94	3.09	0.19
Propionic acid	0.73	0.73	0.65	0.52	0.83	0.61	0.13
Butyric acid	0.83	0.96	0.86	0.84	0.72	0.63	0.14

$^{a, b, c, d, e}$ means with different superscript on the same row are significantly different.
SEM: Standard error of means
T1= 100% *Brachiaria decumbens;* T2= 60% *Brachiaria decumbens* + 40% BDG
T3= 60% *Brachiaria decumbens* + 30% BDG + 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG + 20% Cassava Peel
T5= 60% *Brachiaria decumbens* + 10% BDG + 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% BDG +40% Cassava Peel.

Table 6. Preference of *Brachairia decumbens* ensiled with cassava peel and brewers dried grain fed wad goat

Parameters	T1	T2	T3	T4	T5	T6	SEM
Coefficient of preference	1.14^{a}	1.05^{b}	0.95^{d}	0.94^{d}	0.89^{e}	1.02^{c}	0.004
Dry matter	864.0^{a}	789.75^{b}	720.78^{d}	713.50^{d}	672.75^{e}	772.50^{c}	2.99
Percentage of preference	19.6^{a}	17.43^{b}	15.90^{d}	13.74^{d}	14.84^{e}	17.04^{c}	0.07
Preference ranking	1st	2nd	4th	6th	5th	3rd	

$^{a, b, c, d, e}$ means with different superscript on the same row are significantly different.
SEM: Standard error of means
T1= 100% *Brachiaria decumbens; T2*= 60% *Brachiaria decumbens* + 40% BDG.
T3= 60% *Brachiaria decumbens* + 30% BDG+ 10% Cassava Peel; T4= 60% *Brachiaria decumbens* + 20% BDG+ 20% Cassava Peel
T5= 60% *Brachiaria decumbens* + 10% BDG+ 30% Cassava Peel; T6= 60% *Brachiaria decumbens* + 0% Brewers Dried Grain +40% Cassava Peel

3.3. Volatile Fatty Acid Analysis of *Brachiaria decumbens* Ensiled with Cassava Peel and Brewer's Dried Grain

The volatile fatty acid analysis of *Brachiaria decumbens* ensiled with cassava peel and brewer's dried grain are presented in Table 5. The lactic acid value ranges from 7.35 to 7.76, with the lowest in T2 and highest in T6. Acetic acid ranges from 2.65 and 3.09, it is highest in T6 and lowest in T2. Propionic acid ranges from 0.52 to 0.83, Butyric acid ranges from 0.63 to 0.96.

3.4. Preference of *Brachairia decumbens* Ensiled with Cassava Peel and Brewers Dried Grain Fed Wad Goat

Table 6 shows the preference of West African Dwarf goat fed *Brachiaria decumbens* ensiled with cassava peel and brewers dried grain. After the experiment, the preference was calculated from the coefficient of preference (Cop) value, Therefore, silage was preferred to be relatively acceptable when Cop was equal or greater than one (1) and assumed to be unacceptable when less than 1 is. In this study Cop of treatment 1, 2, 6 is greater than 1 while treatment 3, 4, 5 is less than 1. The Cop varied between 0.890-1.144. Percentage of preference ranged from 14.84-19.06%. The ranking was based on percentage of preference and the order was T1>T2>T6>T3>T4>T5.

4. Discussion

Good silage usually preserves the original color of the pasture or any forage [20]. The light yellow, brown and deep brown obtained in the present study was in order. It was close to the original color of the grass which was an indicator of good silage that was well preserved [21]. The silage with cassava peel and brewers dried grain exhibit pleasant alcoholic aroma which is an indicator of well – made silage. Kung and Shaver [22] reported that pleasant smell is accepted for good or well-made silage. The temperature of fermenting forage varying from 27-38°C was presumed to produce excellent silage [23]. The temperature of silage with greater levels cassava peel is 30°C and greater than the range (25-27°C) obtained by Babayemi [24] in silage of Guinea grass. The temperature range appears to be the operating temperature for normal silage fermentation, good quality silage should be cooled at opening and at feed out phase having a normal room temperature [13,25]. Bolsen *et al.* [26] reported that any excessive heat production can result in mallard or browning reaction which can reduce the digestibility of protein and fibre component. The useful protein form complexes with carbohydrate and thereby making them less digestible. Temperature is one of the essential factors affecting silage color. The lower the temperature the better the silage, the less color change. The texture of the silage was firm which was expected to be best texture of good silage [22] apart from treatment 1 and treatment 6 that were moderately firm.

The pH values of the silage were within the range of 4.2 - 5.5 classified to be pH for good silage [27]. Generally, pH is one of the simplest and quickest ways of evaluating silage quality. The pH of the silage mixture reduced with increasing level of cassava peel inclusion, showing that addition of cassava peel was effective in improving fermentation characteristic of the grass silage. Properly fermented silage usually has lower pH and has been indicated for better fermentation and elicits longer stability during feed out process. The soluble carbohydrate content is critical for the production of good quality silage because it is the main source of nutrients for the growth of microorganism that produce lactic acid. McDonald *et al.* [25] suggested that the potential of a plant for silage depends on the content of WSC (water-soluble carbohydrate), with desired levels above 8% in DM. However, it is well known that tropical grasses have a low content of soluble carbohydrate. The water-soluble carbohydrate content support the growth of lactic acid bacteria, which produce lactic acid, the main acid responsible for the rapid lowering of the pH [25]. The pH showed that the fermentation process has taken place perfectly [28] and the low pH reflects high lactic acid production [22]. High levels of cassava peel is known for a good source of readily fermentable carbohydrate in T4, T5 and T6 and high level of brewers dried is known for high moisture absorbent capacity in T2. Ammonia N is a by-product of proteolytic degradation of protein and is undesirable in the production of good quality silage.

Although generally thought of as anaerobes, most LAB can grow under aerobic conditions, consuming molecular oxygen and helping to create anaerobic conditions in the plant mass [29]. The increasing population and performance of microorganisms as a result of the addition of cassava peels and BDG caused a decrease in pH. This indicates optimal fermentation process. Cassava peels can stimulate the growth of lactic acid bacteria [30] to accelerate the decrease in environmental pH in the ensilage process, therefore bacteria that are able to live are bacteria that are resistant to acidic conditions [31]. Lactic acid bacteria will degrade carbohydrates into lactic acid which results in a decrease in the pH of the silage.

Growth rates of the lactic acid bacteria (LAB) essential to the initial ensiling fermentation are also affected by temperature, among other parameters (e.g., availability of sugars, degree of an aerobiosis, and moisture levels). Lactic acid bacteria grow most rapidly at temperatures between 27 and 38°C. Below 27°C, their growth is slower, but most fermentation should be complete between 7 to 10 days at these temperatures [29].

Normal fermentation process will provide a growth opportunity for lactic acid bacteria [32] and will increase in number if sufficient media and energy are added [33], and can inhibit other pathogenic bacteria. Propionic bacteria that convert glucose and lactic acid to propionic and acetic acid have been found in silages, but it is doubtful that natural populations can flourish in most silages. High concentrations of propionic acid (>0.3–0.5%) are more commonly found in clostridia fermentations [34]. Butyric acid bacteria (BAB) found in silage come from soil accidentally included with the plant material during silo filling. They are able to convert lactic acid into butyric acid, hydrogen and carbon dioxide at a relatively low pH. Extensive growth of Butyric acid bacteria can therefore induce a pH increase and the growth of less acid-tolerant spoilage microorganisms. Grass and corn silages are the most important vectors of Butyric acid bacteria transmission to animals [35]. Propionic bacteria that convert glucose and lactic acid to propionic and acetic acid have been found in silages, but it is doubtful that natural populations can flourish in most silages. High concentrations of propionic acid (>0.3–0.5%) are more commonly found in clostridia fermentations [34].

The lactic acid value found in the silage was superior to 3.0%, which characterizes good-quality silage [36,37]. The lactic acid produced by lactic acid bacteria (LAB), has more accented acidification power in comparison with the other acids produced and, therefore, is the main acid responsible for the quick drop and maintenance of pH. It is usually the acid found in the highest concentration in silages, and it contributes the most to the decline in pH during fermentation because it is about 10 to 12 times stronger than any of the other major acids [e.g., acetic acid and propionic acid) found in silages. Zhang and Yu [38] found out that lactic acid content in silage was higher while the pH value, butyric acid, ammonium-N concentration, and the coliform bacteria were lower in high-density silage (600 kg/m^3).

The concentration of lactic acid and buffering capacity of the silage are two of many factors affecting the final pH of silage [39]. T6 silage had the lowest pH. This low pH is an indicative of the efficiency of the cassava peels that acts as substrate for LAB known to increase the lactic acid content of silage [40]. The preponderance of lactic acid in the silage reduces the pH, which helps to stabilize the fermentation of the silage through the inhibition of growth or outright killing of microbe intolerant to low pH.

Acetic acid is the acid found in the second highest concentration in silage, usually ranging from 1 to 3% of dry matter. Similar to lactic acid, the concentration of acetic acid is usually inversely related to DM content. Moderate concentrations of acetic acid in silage can be beneficial because they inhibit yeasts, resulting in improved stability when silage is exposed to air. Excessively high concentrations of acetic acid (>4–6%) are most often detected in extremely wet (>70% moisture) silages characterized by unwanted (but natural) fermentations dominated by enterobacteria, clostridia, or heterolactic acid bacteria [25]. Both propionic acid and acetic acid are weak acids with antifungal effects. Propionic acid is usually undetectable (especially in drier silages or in very low concentrations (<0.1%) in good silages. Higher values of propionic and acetic acids reported for T6 silage imply that this diet had the highest energy contents, which might have been due to cassava peels' addition as an additive. Butyric acid should not be detectable in well-fermented silages. The presence of this acid indicates metabolic activity from clostridia organisms, which leads to large losses of DM and poor recovery of energy [41]. The preponderance of butyric acid in T2 silage also indicates that this diet is more prone to spoilage as preponderant butyric acid indicates ease of spoilage since the higher the butyric contents in silage, the shorter the shelf life. Higher butyric acid contents of silage diets have also been reported to have a depressing effect on DM [42].

The dry matter(DM) content of forage influences fermentation quality of the silage; and optimal DM content ranges from 30%- 40% for good silage making [25]. The dry matter value of the silage in this study ranged within 24.60-43.90 which compared well with [43] and also similar (33.71% to 48.53%) to reports of Binuomote *et al.* [44] on *Brachiaria decumbens* ensiled with cassava leaves and exceeding 30% DM reported by Oliveira *et al* [45] on Elephant Grass silage. The DM increased with the inclusion BDG in the silage mixtures. The increase in DM across diets may be attributed to the relatively high dry matter content of BDG.

The crude protein (CP) of the silage mixture increased with increasing levels of BDG, the value for CP ranged from 9.80 - 18.90%.The CP obtained is above the recommended level of 7-8% that can provide the minimum ammonia level required by the rumen microorganism to support optimum microbial activities [46,47]. This implies that the experimental silage would provide adequate nitrogen requirement by rumen micro-organism to maximally digest the main components of dietary fibre leading to the production of volatile fatty acid which in turn facilitates microbial protein synthesis [48]. The value was however similar to 12.56 - 16.05% reported by Binuomote *et al.*, [44] for *Brachiaria decumbens* ensiled with cassava leaves and millet grain. High crude protein in Treatment 2 may be as a result of high level of BDG.

Ash signifies the total mineral content of a forage or diet. Ash content is useful in assessing the quality grading of the silage and also gives an idea of amount of mineral element present. Ash ranges from 15.80-17.66%. The ash content reported in this study is higher than 7.25-13.10% reported by Abegunde *et al.* [49] for dry banana leave ensiled with cassava peel. The ash content is an indication that the silage diets will be good source of minerals. Ether extract of the silage fell within the range of 3.37-3.68 which is similar to 3.36- 9.90 as reported by [50] also similar to report from Binuomote *et al.*, [44] for ensiled *Brachiaria decumbens* silage but lower than the (3.44- 4.36 %) of Olivieria *et al.*, [45]. However, the range of EE of the silage was below 80g/kg established by NRC [48] as the limit for which reductions would occur in the DM intake by ruminant animals. The result indicates that both cassava peel and BDG improved energy concentration in the silage and could enhance feed utilization. This agrees with the observation of Oliviera [51] who reported improved nutrient utilization in elephant grass ensiled with increasing levels of cassava meal.

The fiber content (ADF, NDF and ADL) have implication on the digestibility of plants. The Neutral detergent fibre (NDF) is the measure of plant cell wall content and also the chemical component of the feed that determine its rate of digestion. NDF is inversely proportional to the digestibility [52]. The value for Neutral detergent fiber ranges from 71.45 to 73.85%. Result showed that cassava peel increased the value of NDF of the treatments. The highest value (73.85%) obtained for this study was higher than the range of 61.5% reported Aregheore *et al*, [53]. The Acid Detergent Lignin (ADL) recorded from this experiment ranged from 23.30-24.60%. The NDF (71.45-73.85%) and ADF (50.65-53.00%) recorded from this experiment are higher than the 57.1-69.8% NDF and 33.00-43.70% ADF reported by [54]. The value for Hemicellulose and cellulose recorded from this experiment ranged from 20.45-23.20% and 27.35-29.05% respectively. The level of fibre fraction in the silage suggests that it would be sufficient to meet the fibre requirement of ruminant.

Calcium value ranged from 0.24-0.26%. Calcium level obtained is higher than the critical level of 3g.kDM as recommended for ruminant in the warm wet climate [55]. Phosphorus value ranges from 0.36 to 0.37%. The Phosphorus level was also higher than the critical level of 2.5g.kgDM for ruminant animals as reported by McDowel *et* al,. [55].

Cafeteria techniques adopted to assess the preference of various silages. When the CoP is equal to 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. From the study, T1, T2, T6 were accepted by the goats as the CoP of the silage was greater than 1 while the animals rejected silage from T3, T4, and T5. However, it had been noted in previous studies [56,57] that coefficient of preference may not be a realistic measure of acceptability of silage by ruminants since it does not take into consideration, the previous experience of the animal or relative important of changing dietary preference of animals.

Percentage of preference on the other hand, appears to be a more realistic index of acceptability since it does not foreclose the possibility of changing dietary preference among livestock [57]. Ikhimoya and Imasuen [58] reported that small ruminants readily accept diets with which they have had previous experience, while Provenza and Cincotta [59] reported that pre-conditioning of small ruminants to a particular diet influence their choice among a variety of diets. Reece [60] indicated that feed intake does not depend on the nutrient composition of the feed alone but other factors such as palatability feed texture, taste mechanism etc. In this study, the percent preference of sheep varied from 13.74-19.60 %. The order of preference was T1 > T2 > T6 > T3 > T4 > T5. Silage intake increased with increasing level of cassava peel in the diet, showing that goats preferred silage with added cassava peel.

5. Conclusion

The result showed that silage quality in term of the color, texture, smell, pH and temperature were similar amongst all treatment expect for treatment 1 and 6 which are moderately firm.

The crude protein increase with the increase in the level of BDG and also it increases the dry matter content of the silage. Cassava peel increases the level of the ash content of the silage. Ensiling of grasses with BDG and cassava peels during the period of abundance be adequate in providing high protein supplement for ruminant during dry season.

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