

Full Length Research

Influence of Varying Levels of Cassava Leaves and Millet Grain on the Silage Quality of *Brachiaria Decumbens*

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This study was designed to evaluate the silage quality, microbial content and proximate composition of *Brachiaria decumbens* ensiled with varying levels of cassava leaves and grinded millet grains. In a completely randomized design, the silages were made as follows: 60 % *Brachiaria decumbens* + 40 % Cassava leaves, (60Bd40Cl), 60 % *Brachiaria decumbens* + 30 % Cassava leaves + 10 % Millet grain (60Bd30Cl10M), 60 % *Brachiaria decumbens*+ 20 % Cassava leaves + 20 % Millet grain (60Bd20Cl20M), 60 % *Brachiaria decumbens* + 10 % Cassava leaves + 30 % Millet grain, (60Bd10Cl30M), 100 % *Brachiaria decumbens* (100Bd) 100 % Cassava leaves (100Cl). After 150 days, the pH values of silages ranged from 3.8 to 5.0 and exhibited significant differences ($P < 0.05$). Silage colours were olive green with white patches (60Bd30Cl10M, 60Bd20Cl20M and 60Bd10Cl30M), olive green (60Bd40Cl), deep olive green (100Bd) to yellowish green (100Cl). All silage combinations had pleasant smell with an observed improving smell with increasing proportion of millet grain. A similar trend was observed for silage texture which was firm but 100Bd had a soft texture. Temperature ranged between 27°C and 29°C. The highest count of lactic acid bacteria and least count of Enterobacteria were observed in 100Cl. All silages were aerobically stable due to the absence of growth of Total Aerobic Bacteria; however 100Bd had a count of 3.3×10^5 . Yeast count was highest in 60Bd40Cl and lowest in 60Bd10Cl30M. Mold count was lowest in 60Bd10Cl30M (5.0×10^3) and highest in 100Bd. All the silages met the minimum crude protein requirement for ruminants. Microbial load of all silages will not have any adverse effect on ruminant animals.

Keyword: Silage, *Brachiariadecumbens*, Microbial count, Proximate composition

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INTRODUCTION

Seasonal shortages in feed supply are major constraints to increasing ruminant productivity in developing countries (Kebreab *et al.*, 2005) causing fluctuations in the availability and quality of these animal meats and products in these areas. Intake of energy, protein and some essential minerals by most ruminants species fall below their maintenance requirements resulting in 'under-nutrition' and low productivity in most animal production systems (Larbi and Olaloku, 2005). The native pasture depreciate rapidly especially in the dry season, hence the need for conservation in form of silage which is not weather dependent like hay, during the rainy season; when they are in abundant supply and high in nutritive value.

The basic principle of silage is to store the surplus forage keeping its stability and nutritional value until it is required to feed the animals. This process takes place in anaerobic condition, where the lactic acid produced by the Lactic acid bacteria (LAB) inhibits the proliferation of spoilage microorganisms, which are less tolerant to acidic conditions. Thus, as the pH values decline, the silage losses decline as well due to the greater conversion of plant soluble carbohydrates (the main substrate for LAB) into lactic acid, with 96.9% rate of energy recovery (MC Donald *et al.*, 1991).

High quality silage depends on the development of favorable microorganisms under anaerobic conditions. Lactic acid bacteria (LAB) are desired microorganism in silage and contribute to a rapidly declining pH, resulting in silage of high hygienic quality (Driehuis and Oude Elferink, 2000). A pH below 4.2 is considered an important key factor (Eurofins, 2010; Driehuis, 2013) for inhibiting growth of contaminating microorganism that may pose a risk to animal health in the human food chain.

Brachiaria decumbens is an important forage grass used for pasture in the tropics because it has exceptional adaptation to acid soils, vigorous growth, ease of establishment and good forage value throughout the year. (Simioni and Valle, 2009). *Brachiaria decumbens* is high in production of dry matter when planted in areas with low rainfall (Mutimura and Everson 2012). *Brachiaria decumbens* produces more dry matter than most tropical grasses during the dry season (Buloet *et al.*, 1994) and is capable of producing 15–27 mt (metric tonnes) dry matter (DM)/hectare/year. It has been reported that the ability to respond to small amounts of rainfall that occurred in the dry season was due to the extensive root system of *Brachiaria decumbens* (Guenni *et al.*, 2002), plants produce new growth rapidly with out-of-season rain events during the dry season and with the break of season. *Brachiaria decumbens* responds well to defoliation either through grazing, harvesting or complete defoliation such as burning (Rika, 1990, Gobius *et al.*, 2001). 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 (Cook *et al.*, 2005; Loch, 1977). Signal grass can be grazed, cut to be fed fresh or to be made into hay.

Cassava (*Manihotesculenta*) is a crop commonly grown in the tropics/subtropics for the production of tubers for human consumption. Its leaves are the most common part of cassava used as feed for animals by farmers in villages. It contains quite high crude protein up to 25 % on dry matter (DM) basis, a nutrient which is generally deficient in feeds for livestock in the tropics. It is a cheap and alternative source of protein which is readily available in peri-urban and village settlements. According to Alli-Balogun *et al.* (2003), cassava foliage contains 91.25 % dry matter (DM), 18.55 % crude protein (CP), 31.41 % neutral detergent fiber (NDF), 29.3 % ash and 14.14 % lignin. Thus, it can potentially be used as a protein source for livestock. However, cassava leaf production is only concentrated during cassava tubers harvest thus, these are abundantly available only in short periods of time. As other forages, cassava leaf cannot stay for long time without any treatment, consequently the excess of cassava leaf are sometimes left in the field underutilized.

Preservation of the excess of cassava leaf available such as through silage making will maximize and improve the efficiency of the excess cassava leaf utilization as feed resource. As silage, the excess of cassava leaf available can be stored and utilized for a longer period of time as a protein feed supplement. Hang (1998), Kayouli and Lee (2000), Ly and Rodríguez (2001) reported that silage making is an appropriate method to conserve cassava leaf as feed. Feeding cassava leaf silage has been reported to increase livestock productivity including milk yield (IITA Annual Report 2004, Kavana *et al.*, 2005) and body weight gain (Nhi, *et al.*, 2001, Bunyeth and Preston 2006).

This study was carried out to determine the microbial composition and silage quality of *Brachiaria decumbens* ensiled as influenced by varied combinations of millet grains and cassava leaves.

MATERIALS AND METHODS

The research was carried out at the Teaching and Research farm Ladoke Akintola University of Technology, Ogbomoso Oyo State. Microbial analysis was carried out at the microbiology laboratory, Department of Biology LAUTECH.

Brachiaria decumbens was harvested from an existing pasture on the Teaching and Research farm after 8 weeks regrowth. Cassava foliage used for the experiment was sourced from commercial cassava farmers around the locality. Millet was brought from near market

Preparation of silage

The harvested cassava foliage and *Brachiaria decumbens* were carted to the ensiling pen for manual chopping using knives. Both grass and cassava foliage were chopped into 2-3 cm lengths for ease of compaction and consolidation for silage. Ten kilogram capacity plastic buckets were used. The plastics were lined internally with polythene sheets. Filling and compaction were done simultaneously to eliminate inherent air with each layer of the grass compacted manually before adding cassava foliage and millet until the containers were filled. The final compaction was made after which the polythene sheet was tied to prevent air from entering the silage. Sand bags and stones were placed on the silage for compaction. The experimental silages were:

- A: 60 % *Brachiaria decumbens* + 40 % Cassava leaves (60Bd40Cl)
 B: 60 % *Brachiaria decumbens* + 30 % Cassava leaves + 10 % Millet (60Bd30Cl10M)
 C: 60 % *Brachiaria decumbens* + 20 % Cassava leaves + 20 % Millet (60Bd20Cl20M)
 D: 60 % *Brachiaria decumbens* + 10 % Cassava leaves + 30 % Millet (60Bd10Cl30M)
 E: 100 % *Brachiaria decumbens* (100Bd)
 F: 100 % Cassava leaves (100Cl)

Microbial Analysis

Silage was opened after 150 days of fermentation; 5 g of each sample was taken into sterile bottles and frozen prior to microbial analysis. One gram of the silage was mixed with 9 ml of sterile water. This was used for serial dilution to 10^3 . The dilutions were then plated on the following media: De-Man-Rogosa-Shape agar (MRS) to detect LAB, Nutrient Agar (NA) to detect aerobic bacteria, Yeast extracts Agar (YEA) for yeast and yeast like fungi, Potato Dextrose Agar (PDA) to detect Mould and Mac Conkey Agar (MAC) to detect enterobacteria according to Taylor *et al.* (1997).

C.F.U = $N \times Wt \times D$ Where; C.F.U = Colony Forming Unit (g/ml); N = Number of colony;
 Wt = Weight of sample (g); D = Dilution factor (ml)

Determination of Silage Quality

Representative samples of silages were taken for physical characteristics (colour, smell and texture), pH and temperature. Temperature was determined by inserting a laboratory thermometer into the silage. The smell, colour and texture of the silages were judged by a 15-man panel that had experience with silage-making and assessment based on:

Table 1: Assessment scale for the sensory characteristics of the silages

PARAMETERS	0	1	2	3	4	5
COLOUR	Very dark	Dark	Olive Yellow	Light olive green	Olive green	Deep olive green
SMELL	Offensive	Poor	Almost pleasant	Fairly pleasant	Pleasant	Very pleasant
TEXTURE	Slimy	Very soft	Soft	Fairly firm	Firm	Very firm

*Adapted from Ososanya and Olorunnisomo (2015)

Proximate analysis

Proximate composition of silage was determined following the general procedures of A.O.A.C. (2005) and these included ash, crude protein, ether extract, and crude fibre. Nitrogen free extract (NFE) was calculated: $NFE = 100 - (\% CP + \% CF + \% EE + \% ash + \% moisture)$.

Mineral analysis

The samples were analyzed for mineral after wet digestion of sample with a mixture of par chloric acid and concentrated nitric acid 1:4. Potassium (K), Calcium (Ca), Magnesium (Mg), Sodium (Na) were determined using atomic absorption spectrophotometer (AAS) model 490 Gallenkamp, London, while Phosphorus (P) was determined by the Phosphovanadomolybdate method (A.O.A.C., 1995).

Statistical analysis

Data generated were analyzed using analysis of variance (ANOVA) by following the procedure of SAS (2002) while Duncan's multiple range test of the same package was used to separate means at a probability of 5 %.

RESULTS

Presented on Table 2 are the physical properties of the ensiled *Brachiaria decumbens* with varied combination of cassava leaves and millet grains. Silage colour varied from Olive green with white patches to deep olive green. Cassava

Table 2: Colour, Smell, Texture, pH and Temperature of varied combination of millet grains and Cassava leaves ensiled with *Brachiariadecumbens*

TREATMENTS	Colour	Smell	Texture	pH	Temperature
60Bd40CI	4.13 ^{ab}	3.93 ^c	3.60 ^{bc}	4.8 ^a	27.7
60Bd,30CI,10M	3.67 ^b	4.07 ^{bc}	3.53 ^c	4.1 ^{bc}	28.0
60Bd,20CI,20M	4.13 ^{ab}	4.53 ^{ab}	3.93 ^b	4.3 ^b	28.7
60Bd,10CI,30M	3.73 ^b	4.53 ^{ab}	3.87 ^{bc}	3.8 ^c	28.1
100Bd	4.53 ^a	2.00 ^d	2.00 ^d	5.0 ^a	28.0
100CI	2.80 ^c	4.60 ^a	4.33 ^a	4.0 ^{bc}	27.5
SEM	0.23	0.20	0.17	0.30	0.55

a, b, c, d= means with different superscript on a column differs significantly (p<0.05)

Bd= *Brachiaria decumbens*, CI= cassava leaves, M= Millet, S.E.M= Standard Error Mean

Table 3: The colony forming unit (CFU) (g/ml) of the microbes in varied combination of millet grains and cassava leaves ensiled with *Brachiaria decumbens*

Treatments	Lactic Acid Bacteria (g/ml x10 ⁵)	Total Aerobic Bacteria (g/ml x10 ⁵)	Enterobacteria (g/ml x10 ⁵)	Yeast (g/ml x10 ⁵)	Mold (g/ml x10 ⁵)
60Bd40CI	1.83 ^c	N-G	1.17 ^d	4.15 ^b	N-G
60Bd30CI10M	2.39 ^b	N-G	1.44 ^c	2.61 ^d	N-G
60Bd20CI20M	1.77 ^{5c}	N-G	1.04 ^e	2.77 ^c	N-G
60Bd10CI30M	2.22 ^b	N-G	1.00 ^e	5.39 ^a	4.50 ^a
100Bd	1.88 ^c	3.25	3.25 ^b	2.56 ^d	2.15 ^b
100CI	2.66 ^a	N-G	7.39 ^a	N-G	N-G
SEM	0.23	0.08	0.15	0.16	0.13

a, b, c, d, e = means with different superscript on a column differs significantly (p<0.05) S.E.M= Standard Error Mean, Bd= *Brachiaria decumbens*; CI= Cassava leaves; M= Millet; N-G= No Growth

leaves ensiled alone had Olive yellow colour. The colours of silages were close to the colours of the fresh samples before ensiling; indicating that addition of millet as additive kept the colour of the silage intact. The smell of the silage differed from one silage to another from pleasant to very pleasant. Statistical differences (P<0.05) were however observed to exist among the silages. The smell ranges from pleasant to fruity. However, *Brachiaria decumbens* ensiled without additives had an almost pleasant smell. The textures of the silages were firm except *Brachiaria decumbens* ensiled without additive; which had soft texture.

The pH values of the silages ranged from 3.8 – 5.0 in 60Bd10CI30M and 100Bd respectively. Significant differences (p<0.05) existed in the pH of ensiled materials in the present study. The temperature of the silage ranged between 27.5°C (100CI) and 28.7°C (60Bd20CI20M).

Presented in Table 3 is the colony forming unit (CFU) (g/ml) of the microbes in varied combination of millet and cassava leaves ensiled with *Brachiaria decumbens*. The microorganisms present in silages significantly differed (p<0.05) except in silages with no growth of organisms. Lactic Acid Bacteria count was highest (2.66x10⁵) in sole cassava leaves (100CI) and least (1.77 x10⁵) in 60Bd20CI20M silage. However between silages 60Bd40CI and 60Bd30CI10M, the LAB count increases with the introduction of millet grains and reduction of cassava leaves. Also, 100Bd was observed to have the highest counts of Total Aerobic Bacteria (3.25x10⁵) and Enterobacteria (3.25x10⁵). However, sole cassava leaves had the least count of enterobacteria. The silage combination of 60Bd40CI had the highest value of Yeast (4.15x10⁵). There was a decrease in yeast count between 60Bd30CI10M, 60Bd20CI20M and 60Bd10CI30M silage as the levels of cassava leaves reduces and millet increases. All silages except 100Bd had no growth of total aerobic bacteria while 60Bd10CI30M and 100Bd had mold growth.

The proximate composition of varied combination of millet grains and cassava leaves ensiled with *Brachiaria decumbens* is as shown in Table 4. Significant differences (p<0.05) existed in all the parameters considered for proximate composition. Dry matter in the present study had the highest value of 48.53% obtained in silage combination

Table 4: Proximate Composition of varied combination of millet grains and cassava leaves ensiled with *Brachiaria decumbens*

Treatments	DM (%)	CP (%)	CF (%)	EE (%)	ASH (%)	NFE (%)
60Bd, 40Cl	33.71 ^b	13.90 ^c	26.10 ^d	4.36 ^a	17.88 ^{ab}	37.76 ^a
60Bd,30Cl,10M	41.10 ^{ab}	15.28 ^b	27.46 ^{bcd}	3.72 ^b	17.15 ^{ab}	36.40 ^{bc}
60Bd,20Cl,20M	39.50 ^{ab}	13.83 ^c	26.20 ^{cd}	3.44 ^b	18.39 ^a	38.16 ^{ab}
60Bd,10Cl,30M	48.53 ^a	16.05 ^a	27.98 ^b	4.30 ^a	17.61 ^{ab}	34.08 ^c
100Bd	39.61 ^{ab}	12.56 ^d	30.57 ^a	4.33 ^a	16.56 ^b	35.98 ^{bc}
100Cl	42.10 ^{ab}	13.52 ^c	27.75 ^{bc}	4.33 ^a	15.03 ^c	39.38 ^a
SEM	1.43	0.18	0.50	0.11	0.42	0.70

^{a,b,c,d} = means with different superscript on a column differs significantly ($p < 0.05$) S.E.M= Standard Error Mean, Bd= *Brachiaria decumbens*, Cl= Cassava leaves, M= Millet; DM= Dry Matter; CP= Crude protein; CF= Crude fiber; EE= Ether Extract; NFE= Nitrogen Free Extract;

Table 5: Mineral Composition of ensiled *Brachiaria decumbens*, cassava leaves and millet mixture.

Treatment	CCa	PP	MMg	KK	NNa	CCa:P
660BD40CL	00.21 ^c	00.22 ^b	00.14 ^b	00.36 ^{bc}	00.11 ^{cd}	11.04
660BD30CL10M	00.20 ^c	00.25 ^a	00.15 ^b	00.38 ^{bc}	00.12 ^b	01.25
660BD20CL20M	00.24 ^a	00.22 ^b	00.15 ^b	00.39 ^{ab}	00.11 ^d	01.09
660BD10CL30M	00.22 ^{bc}	00.24 ^{ab}	00.15 ^b	00.39 ^{ab}	00.11 ^{bc}	01.09
1100BD	00.22 ^{bc}	00.23 ^{ab}	00.16 ^a	00.12 ^c	00.41 ^a	01.04
1100CL	00.23 ^{ab}	00.23 ^{ab}	00.16 ^a	00.41 ^a	00.12 ^b	01.00
SSEM	00.003	00.003	00.001	00.0004	00.001	00.00

^{a,b,c,d} Mean with in the same row with different superscripts are significantly ($P < 0.05$) BD= *Brachiaria decumbens*, CL= Cassava leaf, SEM= Standard Error of Mean, M= Millet Ca= Calcium; P= Phosphorus; Mg= Magnesium; K= Potassium; Na= Sodium;

of 60Bd10Cl30M while the least value (33.71%) was from 60Bd40Cl. The crude protein values ranged from 12.56 % in 100 % *Brachiaria decumbens* silage to 16.05 % in 60Bd10Cl30M. Except for the 60Bd20Cl20M, increasing millet in the combination led to increase in the CP content of the silage. The highest value for Crude fibre was from 100Bd silage (30.57 %) while the least was observed in 60Bd40Cl (26.10 %). Ether extract had its highest value in 100Bd and 100Cl (4.33 %) while the least value was in 60Bd20Cl20M. Values obtained for ash in the present study was the highest in 60Bd20Cl20M (18.39 %) and least in 100Cl (15.03%).

All the minerals in the present study (Table 5) exhibited significant differences ($P < 0.05$) among silages except calcium: phosphorus ratio. Potassium (K) ranged from 0.12 % (100Bd) to 0.41 % in 100Cl. while Sodium (Na) has the lowest value in silage that 60BD30CL10M (0.12%) and 60BD40CL (0.11) respectively. However, the highest value in calcium was obtained in the silage 60BD20CL20M (0.24%). As the level of millet increases in the silage 60BD10CL30M, the amount of calcium decrease. In phosphorus, the highest value was also obtained in 60BD30CL10M (0.25%), as level of millet increased (60BD20CL20M), level of phosphorus in the silage decreased (0.22%). The highest value of magnesium (Mg) (0.16%). In sole 100% BD and 100% CL as However, there lowest value was obtained in 60% BD and 40% CL (0.14%).

DISCUSSION

Ensiling is a preservation method for moist forage crops. It is based on lactic acid bacteria (LAB) converting water soluble carbohydrates (WSC) into organic acids, mainly lactic acid, under anaerobic conditions. Tropical forages are reportedly (Moran, 2005) difficult to ensile because of their high buffering capacity hence the addition of a fermentable substrate at ensiling in order to enable a more satisfactory fermentation is essential. The presence of readily fermentable carbohydrates for the metabolism of lactic acid producing bacteria has also been reported to prevent to some extent the activities of clostridia which spoil silages and cause pH to be low. As a result, pH decreases and the moist forages are preserved from spoilage microorganisms (McDonald *et al.*, 1991).

The pH of silages measures the degree of acidity but is also affected by the buffering capacity of the crops. Kung and Shaver (2002) in their interpretation of silage analysis stated that good quality grass and legume silage pH values in the

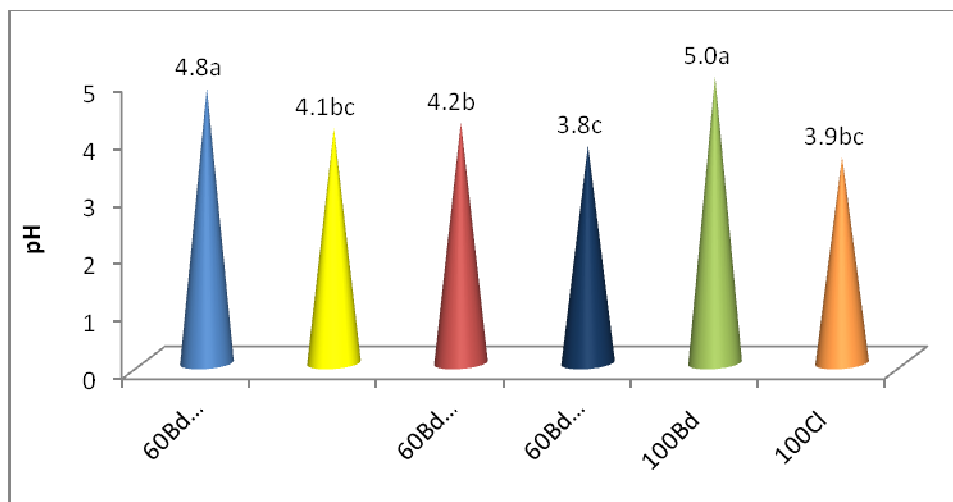


Figure 1 :The pH of varied combination of millet grains and Cassava leaves ensiled with *Brachiaria decumbens*

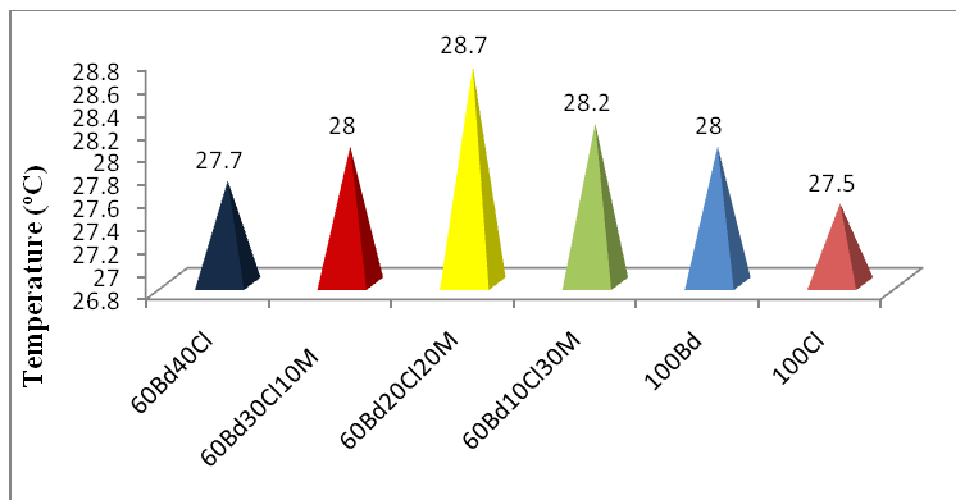


Figure 2: The Temperature of varied combination of millet grains and Cassava leaves ensiled with *Brachiaria decumbens*

tropics range between 4.3 and 4.7. However, Weissbach (1996), presented a critical pH limit for good silages depending on the dry matter content in which pH should be no higher than $0.025 \times \text{DM}$ (expressed as percentage) + 3.71. The silages in the present study with combinations of cassava leaves and millet conformed to this recommended range and it is an indication that these additives enhanced the preservation of *Brachiaria decumbens* as silage. High levels of millet grains, known for high moisture absorbent capacity and a source of readily fermentable carbohydrate could have been responsible for the lowering of pH observed for 60Bd20Cl20M and 60Bd10Cl30M. The final pH of silage is affected by many factors but is most related to the concentration of lactic acid and buffering capacity of the crop.

The olive green colour observed for the silages can be regarded as being in order as it corresponded with past findings (Oduguwa *et al.*, 2007; Babayemi, 2009). The olive green colour reflects the original colour of the ensiled *Brachiaria decumbens* and Cassava leaves, an attribute regarded (Oduguwa *et al.*, 2007; Babayemi, 2009) as an indication of good quality silage that has been well preserved.

Also, Kung and Shaver (2002) reported that pleasant smell is accepted for good or well-made silage. The results from

this study suggested that increasing inclusion levels of millet could have improved the aroma of the millet based silages as confirmed by the smell ratings. The texture of the silages from this study were firm, which was expected to be the best texture of good silage (Kung and Shaver, 2002) except for sole *Brachiaria decumbens* which had soft texture. This could be attributed to the absence of millet grains known for high moisture absorbent capacity.

The temperature of fermenting forage varying from 27-38 °C was presumed to produce excellent silage (Muck, 1996). Temperature from this study ranges from 27-29 °C. The mean overall ratings support the observed trends of improvement of silage quality by the addition of millet grains.

The main process associated with ensiling is the fermentation of sugars by lactic acid bacteria. Once the forages are anaerobic, lactic acid bacteria grow rapidly and quickly become, in most cases, the dominant microorganisms on the crop. Thus in these forages the need to wilt the crop to a high DM content (reducing the amount of fermentation needed to inhibit the clostridia) or use an additive to achieve a lower pH than is possible by natural fermentation. Increase in pH is an indicator of microbial activity responsible for the deterioration of the fermented feedstuff, and thus of aerobic stability (Woolford, 1984). These factors (high DM of 48.53% and high level of millet additive) could be attributed to the high count of LAB observed in 60Bd10Cl30M silage. Adesogan, (2006) also reported that high temperatures reduced LAB populations as observed in silage 60Bd20Cl20M which has a temperature of 28.7°C and the least LAB count of 1.68×10^5 .

The principal bacterial competitors of the lactic acid bacteria under anaerobic conditions (enterobacteria, clostridia and bacilli) were all inhibited due to a sufficiently low pH because fermentation by the lactic acid bacteria usually takes silage pH to a level (below 4.5-5.0) that inhibits these bacteria (Muck, 2010). Rapid drop to a low pH reduces the activity of enterobacteria and their effects on silage quality. The enterobacteria count of the silage combination of 60Bd10Cl30M with a low pH value of 3.8 was 1.0×10^5 which falls within the range of 10^3 - 10^6 reported by Pahlow *et al.*, (2003) as the level of the population of enterobacteria before ensiling indicating that the intake of the silage will have no adverse effect on the health of animals. Once anaerobic conditions are established lactic acid bacteria dominate the fermentation of crops in the silo. While bacteria on fresh forage are mainly aerobic, they are normally quickly replaced by anaerobes as silage fermentation proceeds. This can occur only after good packing and elimination of air, however because the survival of aerobic organism depends on oxygen, whose presence promote maximum degradation and poor preservation. If lactic acid-producing organisms dominate then pH is low and preservation is maximal. Non-lactic fermenters (e.g Clostridia) metabolize lactic acid but are inhibited by low pH and osmotic pressure (Van soet 1994). Lactic acid bacteria have several mechanisms that might explain their dominance (Pahlow *et al.*, 2003). First, many can grow in aerobic conditions and a common end-product of their activity under aerobic conditions is hydrogen peroxide (Condon, 1987), which can kill other microorganisms and in some cases accumulate sufficiently to inhibit the lactic acid bacteria too. Various strains of lactic acid bacteria produce bacteriocins that can inhibit other microorganisms (Gollop, *et al.*, 2005); their dominance may only depend on rapid growth under anaerobic conditions.

Enterobacteria are also the principal competitors of the lactic acid bacteria for the sugars in the crop. Their principal fermentation product is acetic acid, not lactic. Other fermentation products in silage that are signs of their presence are succinic acid and 2,3-butanediol. As a consequence, their fermentation is less desirable than that of lactic acid bacteria. (Pahlow *et al.*, 2003)

Yeasts are perhaps the most significant aerobic microorganisms on the crop relative to silage quality. Yeasts grow on soluble substrates, sugars and lactic acid being the most important relative to silage. According to Pahlow *et al.*, (2003), yeasts population prior to ensiling ranges between 10^3 - 10^5 . However, yeast populations can reach up to 10^7 colony forming units per gram during the first weeks of ensiling but prolonged storage will lead to a gradual decrease in yeast numbers (Driehuis and Van Wixselaar, 1996). Prolonged storage could be attributed to the range of yeast population in all silage combinations obtained from this study. Meanwhile, lactic acid bacterial fermentation rarely lowers pH sufficiently to prevent yeasts and molds from growing in silage. Many yeasts and molds are capable of growing at pH 3.5, because they are acid tolerant (Mc Donald *et al.*, 1991). Once oxygen is present, yeasts and molds begins to grow on silage, using fermentation products and residual sugars in the silage and producing carbon dioxide, water and heat. As fermentation products are used up, silage pH rises and once the pH is above 4.5, a wide variety of other aerobic microorganisms can grow, causing spoilage more and greater heating of the silage. Also, the higher pH together with the restricted activity of lactic acid bacteria would also facilitate yeast development. This is confirmed in silages 60Bd40Cl and 100Bd. Silage 100Bd had high count of mold and this could be ascribed to its soft texture. Yeasts are also important because some species can grow anaerobically, fermenting sugars to ethanol. When silages have substantial levels of sugars remaining after the lactic acid bacteria are inhibited by low pH, yeasts may develop and are the presumed cause of most high ethanol silages (>20 g/kg dry matter [DM]) (Pahlow *et al.*, 2003). Molds are also of concern because of their production of mycotoxins. These microorganisms are strictly aerobic. By comparison with other microorganisms in silage, they are on average the slowest growers. While they can grow on a wide variety of compounds, they rarely are apparent or at sufficient population to affect gross measures of silage quality until the silage have undergone substantial aerobic deterioration by yeasts and various aerobic bacteria (Pahlow *et al.*, 2003). It was

observed that mold did not grow on most of the silages in the present study. They were found on 60*Bd*10*Ci*30*M* and 100*Bd* only. Once oxygen is present, yeasts, molds and acetic acid bacteria begin to grow on silage, using fermentation products and residual sugars in the silage and producing carbon dioxide, water and heat. As fermentation products are used up, silage pH rises. Once the pH is above 4.5, a wide variety of other aerobic microorganisms can grow, spoiling the silage more and causing even greater heating of the silage. All of these losses are of the most digestible parts of the silage. The present study indicated quality silage in that the temperatures and pH were within the normal range and the microorganisms considered also fell within range.

The DM contents of the silage mixtures were observed to lie within 33.0 % to 49.0 %. Increasing proportions of millet grains in the silage combinations resulted in increasing DM contents with significant ($P < 0.05$) differences at 10 and 30 % inclusion levels. This trend could be reflective of the DM contents of the materials ensiled. However, the DM range fell within reported (Buxton *et al.*, 2003) adequate range for silages. The CP values of the silages (12.56- 16.05 %) in this study was more than 8% level required for optimum rumen microbial activity (Norton, 1994) and as a minimum crude protein (10 – 12 %) recommended for ruminants by ARC (1980). Crude fibre measures the cellulose, hemicellulose and lignin content of forages, however, high levels of crude fibre affect the digestibility of diets. The level of fibre fraction in the silages suggests that it could be sufficient to meet the fibre requirement of the ruminants. The CF content was higher than the range of 15-20% recommended for improve intake and production in finishing ruminants (Buxton, 1996). Seglar, (2003) reported the range of ash to be 10-20 g/100 DM similar results were observed in the present study.

The Calcium (Ca) concentration in the silages meet the recommended requirement for growth (0.29 %) and lactation (0.22 %) in Cattle (ARC, 1980), a range of 0.2- 0.82 % for sheep (NRC, 1985) and 0.15% DM, the desirable concentration of mineral in feed dry matter for maintenance for sheep (SCA, 1990) was met in this study. It also meets the net P requirement for growth (0.19 %) and lactation (0.17 %) for cattle (ARC, 1980), 0.15- 0.38% DM for goat (NRC, 1985) and 0.13% DM for sheep maintenance (SCA, 1990). Potassium (K) fell within the required range (0.10-0.5%) for sheep recommended by NRC 1985 but lower than 0.80% recommended for grazing animals (Underwood, 1981). Magnesium (Mg) concentration of all silages (0.14- 0.16 %) meets Mg requirement in ewes – late pregnancy (0.15%) and early lactation 0.18% and higher than 0.12-0.20 % (NRC, 1985; SCA(1990) for growth and maintenance in sheep. It was however lower than recommendation of Haelein (1987) for dairy goat (0.2%) and that of ARC (1980) for growing sheep (0.21%). According to NRC 1985, sodium (Na) requirement for sheep is 0.18 %, however the sodium results from this study did not meet the requirement of the animal (0.11 to 0.41%). Hence, the silages can be mixed with common salt to supplement this discrepancy. Calcium (Ca) and phosphorus (P) are two macro or major mineral required in a ration in relatively large amount. The Ca:P ratio was within the range required by sheep (1.0-1.6) (Fujihara *et al.*, 1995). The high content of mineral (Ca, P, Na) indicated that the requirements of sheep and goat for these mineral could be met (MC Dowell, 1997).

CONCLUSION

Ensiling preserved *Brachiaria decumbens* with the aid of additives; cassava leaves and millet grains in varying levels. Resulting low pH primarily suppressed the growth of aerobic microorganisms. The fermentation also inhibited yeasts, molds and aerobic bacteria, but the anaerobic environment helped to prevent most of the spoilage microorganisms from growing. The making of silage in the present study did not negatively affect the proximate composition and minerals of the silages. *Brachiaria decumbens* ensiled with Cassava leaves (10 %) and millet grains (30 %) is recommended for feeding ruminants due to its composition.

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