

**EFFECT OF STAGE OF MATURITY AND FORAGE BOTANICAL
COMPOSITION AT ENSILAGE ON NUTRITIVE VALUE OF
COLUMBUS GRASS (SORGHUM ALMUM)SILAGE**

BY

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COMPOSITION AT ENSILAGE ON NUTRITIVE VALUE OF
COLUMBUS GRASS (SORGHUM ALMUM) SILAGE**

By

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Ahmadu Bello University,
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for the degree of Master of Science.**

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CERTIFICATION

This thesis entitled "Effect of stage of maturity and forage botanical composition at ensilage on nutritive value of Columbus grass (Sorghum alnum) silage" by Mohammed Baba meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.



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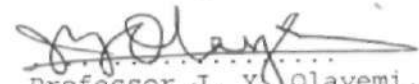
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DECLARATION

I hereby declare that the whole of the work submitted as thesis for the Master of Science degree (Animal Science) of Ahmadu Bello University is the result of my investigations (except where reference is made to published literature and where assistance is acknowledged) and has not been part of any presentation for any other qualification.

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Mohammed Baba

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DEDICATION

This thesis is dedicated to my dear mother, Hajiya Adama Mohammed.

ABSTRACT

A study was conducted on field grown columbus grass (Sorghum almum) at the National Animal Production Research Institute (NAPRI), Shika, Ahmadu Bello University, Zaria, Nigeria during the rainy season of 1992. The objective of the trial was to determine the ensiling characteristics of the forage at five maturity stages and evaluate the nutritive potentials of the resultant silages in ruminant feeding systems. Forage sown on 30th July, 1992 was harvested at pasture stages of 50, 60, 70, 80, and 90 days post-planting and ensiled fresh in laboratory silos. Following an incubation period of 21 days the resultant silage was scored for colour and aroma. The pH was determined and sample analyzed for nutrient constituents.

The forage declined in moisture content (85.1 to 54.6%) and leafiness (46.0 to 26.0%) with time to maturity. Bloom content and fodder yield rose (10.3 to 95.1% and 1.3-8.40t DM/ha) with time to maturity. Fodder accumulation was rapid with mean daily increment of 177.0kg DM/ha within the growing period.

Forage materials at all phenological stages resulted in satisfactory silages with agreeable colour and aroma. The materials consolidated well and fermentation was complete with moderately acidic pH values (4.6 to 4.1). The HCN concentration was low and declined with stage of maturity (244.0 to 183.0 mg HCN/kg DM). Plant factors favouring digestibility such as CP, EE and carotene declined with stage of maturity, while structural constituents (NDF and ADF) showed positive relations. Silages of the late vegetative to the hard dough stages declined in contents of N, P, K, Na and Fe. There was no consistent trend in concentrations of Ca, Mg and Cu, while the concentration of the Mn was fairly constant. Based on ruminant nutritional standards the nutrient composition of the silages are apparently sufficient in supplying the requirement

of N, Ca, Mg, Mn, Fe, Cu and carotene for production. The silages are deficient in P and border-line in Na concentration.

Results in this study indicate that satisfactory silages were obtained from columbus grass (*S. alnum*) at varying phenological stages from the late vegetative to the hard dough stages (i.e., 50 to 90 days post-planting). As a compromise between fodder yield and nutritional quality, the soft dough stage (ca 80 days post-planting) is recommended as the optimum stage of harvesting the forage material for ensiling. Such silage could however be deficient in N, P, and Na relative to the requirements of ruminant for productive functions. Supplementation of these nutrients may thus be essential. Animal studies involving feeding trials are advocated to elucidate and further define the limits of the *S. alnum* silage in ruminant feeding systems.

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CHAPTER ONE

INTRODUCTION

One of the major problems confronting animal production in Nigeria is the wide variability in the availability and quality of feed for livestock over the feeding/grazing period. There are extremes of abundant and acute shortage of fodder supply attributable to the seasonal variation in weather and climate (van Raay and de Leeuw, 1971). Also quality in terms of digestible matter varies with seasons.

The bulk of Nigerian livestock population is concentrated in the Sahel-Sudan and Northern Guinea savannas of the country. Production is under free range grazing of fodders. The savanna has two distinct seasons, i.e, hot-dry and rainy seasons. Fodder production in terms of quality and quantity follow the patterns observed in the seasons. During the rainy season, particularly towards crop harvesting period, there is usually an abundance of forage supply. Animals during the period are in good condition and perform satisfactorily on fodder grazed in situ. At peak dry season, with the depletion of crop residues and forage supply from native rangelands coupled with grazing and bush fires, the consequences are inadequate supply of feed, and loss of body weight, low milk yield and poor reproductive performance of livestock (FAO 1983).

The abundant fodder supply at peak growing and crop harvesting seasons can be more efficiently utilised through conservation practices for later use during the dry season. Fodders may be conserved in one of several ways:

- (a) Standing hay grazed in situ
- (b) Cut dried hay
- (c) Cut fresh and processed e.g as pellets.
- (d) Cut moist and ensiled.

In Nigeria, as in most tropical countries, hay making is beset with problems of loss in quality as dry weather must prevail to ensure good quality hay. There are still no artificial driers to handle bulky forages. This necessitates delaying hay making till the end of the rains. But by then and with the on-set of dry season there is rapid decline in nutrient quality in most tropical forages due to lignification and increase in structural components. Moreover, with perennial bush fires most fields are destroyed before sufficient hays could be made. Pelleting is not realistic as this would require mechanical equipment with heavy investment in capital.

Ensilage is the conservation of forage crops by controlled fermentation. Chemically the process involves degradation of soluble carbohydrates into lactic acid with final pH in the region of 3.8 to 4.2 (Miller 1969). Silage is a promising option for conservation of forages during the growing season. Surplus fodder during the later part of the growing season can be ensiled for use in the dry season while allowing regrowth that can also provide adequate grazing by the end of the rains. Silage has its own intrinsic advantages. Well prepared silage contains high proportion of nutrients, since forages meant for silage can be harvested at an early stage when their nutritive is high (Manda et al., 1980).

The objectives of this study were: i. to investigate the ensiling characteristics and ii. determine the maturity stage most optimum for preparing silage of columbus grass (Sorghum almum). Phenology of the pasture and nutritive value indices of silage and relations among nutrient components were examined.

CHARTER TWO
LITERATURE REVIEW

2.1 DESCRIPTION

Sorghum alnum (columbus grass) is a densely, tufted, perennial grass with high potential for use in intensive livestock production in Nigeria (Muhammad, 1993 and Muhammad *et al.*, 1994). Sorghum alnum was considered to be a hybrid between S. halpense, which grew in Argentina as a weed, and a cultivated forage sorghum (Sorghum sudanenses). It is also suggested that S. alnum may have originated from a cross between S. halpense and grain sorghum (Sorghum bicolor). It is a stable and balanced hybrid which does not normally segregate into parental types (Bogdan, 1977).

Soon after its recognition as a species, S. alnum was introduced into cultivation in Argentina where it was grown on a large scale in the 1940s as pasture crop. From Argentina the grass was later introduced into South Africa where it became one of the most important fodder plants (Narayanam and Dabadghao, 1972). It was often referred to as the "five sorghum" because of its perennial habit as it lasts up to five years or longer following establishment. It has been successfully tried in U.S.A, Australia, and in a number of countries with tropical and sub-tropical climates. Cultivation of S. alnum was for some time prohibited in some states of U.S.A because it was feared that the rhizomatous grass could become a serious weed. It was however proved to be non-aggressive. The short rhizomes did not spread far from the mother plant and the ban on seed production was lifted (Martin *et al.* 1976). The grass is valued for its good production, its perennial habit, ease of establishment, drought and salt resistance, reasonably high yields, and good quality of herbage (Bogdan, 1977).

2.2 Environment

Sorghum alnum is grown with good success in warm, dry climates but can withstand a certain degree of frost. In Georgia, U.S.A. it survived a winter temperature of -15°C (Davies and Edey, 1959). It is a drought-resistant species and recommended in South and East Africa for areas with annual rainfall of 400 to 600 mm and in Australia up to 750 mm (Narayanam and Dabadghao 1972; Bogdan, 1977). Black et al. (1980) reported that sorghum has the ability to recover from drought and therefore more valuable than corn in areas of low rainfall. It goes dormant in periods of drought and resumes growth as soon as there is sufficient rain. In more humid areas, the crop become more susceptible to leaf diseases similar to those of grain sorghum (S. bicolor).

Sorghum alnum can grow in a variety of soils. The best seems to be black soils of grey and brown, saline as well as alluvial soils. The established plants do not tolerate flooding. It can withstand moderate salinity (Martin et al. 1976; Bogdan, 1977). It competes successfully and outgrows most annual weeds including Eleusine indica, Digitaria, and Amaranthus spp in the Northern Guinea savanna zone of Nigeria (Muhammad, 1993).

2.3 Establishment

Sorghum alnum is normally grown from seed as broadcast or, better drilled in rows of 80-100cm apart although closer spacing is also used particularly when the forage is intended for silage production. Seed rate ranges from 7kg/ha for wide spaced rows and up to 20 to 25kg for broadcasting or close row planting (Bogdan, 1977; Narayanam and Dabadghao 1972). It was successfully grown in Australia in burnt brigalow bush by sowing into ash (Bogdan, 1977; Yates et al. 1964). Weeding and

N-fertilization had been found desirable in enhancing tillering and improved establishment (Muhammad, 1993).

2.4 Planting Date

Planting date is important in pasture establishment in order to reduce weed infestation and produce high forage yield. Agishi (1971) recommended late June to early July as the optimum time for planting pastures in the Northern Guinea Savanna Zone. In recent studies with Sorghum alnum, Muhammad (1993) recommended mid-June to early - July plantings when rains are well established as superior to either earlier or later plantings with forage yields attaining up to 8.1 to 11.4 t/ha in the year of establishment.

2.5 Effect of Stage of Maturity on Nutrient Composition of Silage

Stage of maturity has great influence on the nutritive value and intake of silage. Izumi (1988) indicated that second cut silage made from Phaleum pratense was lower in nutrients than 1st cut silage. Nutritive value and intake declined with maturity after heading began. It was also observed, in the same study, that the nutritive value of maize silage was higher in early than late maturing cultivar. Similarly, Manda et al. (1980) found that the quality of silver grass (Miscanthus sinensis) silage was higher at vegetative stage than at maturity.

Srivastava and Kushwaha (1971) observed that contents of dry matter, organic matter, crude fibre and nitrogen free extract increased with age while those of CP, ether extract, ash, Ca, Mg. and P decreased in Andropogon-sorghum. Sherrod et al (1968) reported that yields of total protein and total digestible nutrients (TDN) in forage sorghum decreased with

increasing maturity with the milk ripe stage being the most optimum stage for cutting. In five sorghum hybrids crude protein content was found to be higher at vegetative stage compared to the amounts at heading and hard dough stage (Miaki et al, 1983). Gupta and Pradhan (1975) in trials with pearl millet, (Pennisetum americanum) sorghum, maize, oats, "kyasuwa" grass (P. pedicellatum) and teosinte reported that crude protein and total cell contents decreased while dry matter and cell wall contents increased with increasing age in all the species. Majumdar and Rakib (1980) reported a decrease in lactic acid, ammonia-N and crude protein, and a corresponding increase in neutral detergent fibre contents of sorghum, maize, pearl millet and "Kyasuwa" silages with increased maturity. Andrade and Andrade (1982), in a field trial using pearl millet observed higher yield of dry matter and crude protein content of silage in early than late cut silage materials with resultant increase in crude fibre content. Okamoto (1986) reported that as maize matured, percentage DM, crude starch and energy content increased with corresponding decreases in the percentages of crude protein and acid detergent fibre. Ye et al (1986) also reported that forage cut at late boot stage had significantly higher DM and NDF contents than at medium dough stage.

2.6 Influence of Stage of Maturity on Fermentation Characteristics and Rumen pH.

Okamoto (1986), reported that in maize silage harvested at full ripe stage, rumen pH was higher and total rumen volatile fatty acid content was lower than that harvested at milk-ripe or yellow-ripe stage which suggests that pH increases with maturity thereby resulting in poor fermentation which consequently results in production of poor quality silage. Paditharatre et al, (1986), observed that cutting grass at 2 weeks decreased pH and increased lactic acid concentration

compared with cutting at 3 weeks which indicates that lactic acid bacteria work best at a low pH. The proportion of acetic acid in rumen liquor decreased with increasing crop maturity (Nakui et al, 1988).

2.7 Effect of stage of Maturity on Digestibility of Nutrients

Sarwatt et al (1989) reported that silages made from maize (Zea mays), guinea grass (Panicum maximum) and Jaragua grass (Hyparrhenia rufa) harvested at the pre-flowering stage had a significantly higher organic matter, crude protein and crude fibre digestibility than that made from herbage harvested at the post flowering stage of growth. Fitzgerald (1987) reported that delayed harvesting resulted in increased yields but reduced silage DM digestibility which in turn reduced DM intake. In the study above, it was observed that for each 1% decrease in silage DM digestibility, silage intake was reduced by about 50g/DMD day. When six dry cows were given Trifolium repens (red clover), Medicago sativa, (alfalfa), bromegrass (Bromus spp) and timothy (Phaleum) silages as sole feeds, dry matter intake was greater with early cut than late cut silages and digestibilities of DM, CP, ADF and NDF were also higher for the early cut silage, similar to data obtained by Clark and Bull (1986) and Thomas et al. (1988). This is also similar to the results of Okamoto (1986), which indicated that the digestibilities of CP, CF and ADF at milk stage were higher in maize silages made at yellow than those at full ripe stage.

2.8 Influence of Stage of Maturity on the Performance of Animal

Silages made from forages harvested at early stage have been found to influence the performance of animals more

positively than those harvested at late mature stages. Valdez et al. (1984), for example, had reported higher total milk yield, DM intake and total rumen VFA concentrations in cows given diets containing early maturing maize compared to those on diets of late maturing maize. The latter group were however found to have resulted in higher milk fat and feed efficiency. Similarly, early cutting of perennial rye grass for silage increased energy retention and improved daily gains of body weight, fat, and protein (Thomas et al. 1988) in cattle fed such silage. The results confirmed report by Steen (1984) who observed a significantly higher intake, live weight gain and carcass weight for early cut than late cut silage of perennial rye grass. Silage dry matter intake, body weight, milk production and milk quality (fat and casein) in Holstein cows were found to be significantly higher on corn and timothy/ladino clover silages of late yellow ripe stage compared to those made at heading or later flowering stage (Izumi et al. 1982).

2.9 Effect of stage of Maturity on Hydrocyanic Acid

Martin et al (1976) reported that hydrocyanic acid in forage sorghum hybrids decreased with maturity. In the report while in the boot stage hydrocyanic acid content of the leaf was indicated to be 3-5 times higher than that of the corresponding portions of the stalk, heads and sheaths. The upper leaves contain more prussic acid than the older, lower leaves. The cyanide potential of forage sorghum was found to be moderately low with, 0.016% HCN in dry matter, 0.021% - 0.003% in mature leaves, and 0.03% HCN in short basal tillers (Wheeler et al. 1975).

Sorghum alnum is a recently introduced forage species in Nigeria. It is a promising forage crop with high potential for possible integration into the livestock production systems

of Nigeria. It has been found to have a wide range of environmental adaptation from the semi-arid to the sub-humid part of the country with rainfall regimes between 600 and 1100mm with promising fodder yields and favourable animal responses (Muhammad et al 1994).

So far work on the species has been on its hay production potential (Muhammad 1993, and Muhammad et al. 1994). It is yet to be evaluated for silage production characteristics. Ease of establishment, rapid growth and high yields mark out Sorghum alnum as a suitable candidate for silage making during the rains and in situ grazing of the regrowth from cuts. The objective of this study was to determine silage production characteristics and the nutritive value of the resultant silages of the forage materials harvested at various stages of maturity. The ensiling characteristics of the forage materials and the nutritive value of the resultant silages of the forage harvested at various stages of growth were examined.

CHAPTER THREE
MATERIALS AND METHODS

3.1 The Study Area.

The experiment was conducted at the National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria. Shika is located at 11° to $11^{\circ} 13'$ N and $6^{\circ} 55'$ to $7^{\circ} 33'$ E, on an altitude of about 628m above sea level. The climatic conditions (rainfall, temperature, sun shine and relative humidity) during the growing season of the study year are shown in Table 1. The area falls within the Northern Guinea savanna ecological zone. The climate of the area is characterized by distinct wet and dry seasons. It is normally wet from May to October and dry from November to April. Mean total annual rainfall varies from 800 to 1300mm with long-term average of 1050mm. Both temperature and relative humidity show seasonal and diurnal variations. The highest mean air temperatures (ca 28.3°C) are recorded in April and May, while the lowest temperatures (ca 21.8°C) are recorded in December and January (Kowal and Knabe 1972).

Table 1. Mean monthly rainfall, temperature, relative humidity and sunshine during the growing season of the study in 1992.

Months	Rainfall (MM)	Temp ($^{\circ}\text{C}$)	R.H (%)	SS (Hours)
June	190	26	77	6.3
July	205	24	80	6.0
August	290	23	84	5.0
September	90	26	70	8.0
October	20	26	50	9.0
November	-	23	28	9.5

3.2 The Experimental Pasture

The pasture from which the forage materials for silage preparations were obtained was a four-hectare forage sorghum (Sorghum alnum) field sown on July 30th, 1992 on a field previously cultivated to maize (Zea mays) following a five-year fallow period. Seeds mixed with fertilizer in the form of 15-15-15 NPK were drilled on clean seedbed following ploughing and harrowing. The mixture was calibrated to provide a seeding rate of 15kg/ha and fertilizer rate of 100 kgN/ha. Three weeks later, weeds were controlled mechanically by earthing up with ox-drawn plough. The common weeds then were: Sporobolus pyramidalis, Cassia tora, Amaranthus spinosa, Tephrosia spp, Eleusine indica, Cynodon dactylon and annual species of Digitaria.

3.3 Pasture Sampling

Fifty days post-planting (17th September, 1992) while in the late vegetative/early boot stage and subsequently at ten-day intervals the pasture was sampled to monitor its characteristics and to obtain forage materials for silage preparation. The last sampling was taken 90 days post-planting (27th October, 1992) when the pasture was at soft or hard dough stage. At this stage over 95% of plants had full inflorescence and brown senescent leaves well above the mid-stem height.

On each sampling day the entire pasture was traversed and quadrat was placed at five random locations for pasture analysis. At each quadrat location plant density (as number of culms, boots and/or fully expanded inflorescences) were recorded. Thereafter, forage enclosed within the quadrat was harvested to 10cm above ground level and fresh weight determined. The harvested forage from all quadrat locations

were bulked and thoroughly mixed. Two representative grab samples were then taken from each bulk. One was separated into leaf and stem for determining forage leafiness (on fresh weight basis) while the other was saved for use in preparing silages.

3.4 Silage Preparation

Silages were prepared in vitro from forage samples harvested at the pasture stage of 50, 60, 70, 80 and 90 days post-planting using wide-mouthed kilner jars (Cope BS 910-8, 1000ml). Five replicate silage preparations were made for each pasture stage. At ensilage whole plant samples were chopped into 1-cm length pieces and tightly packed into the jars till they were filled to the brim. The mouth of the jars were greased and then tightly sealed with screw covers to provide airtight, anaerobic condition and promote fermentation. The jars were then kept under room conditions (26°C) for an incubation period of 21 days.

Following the 21 days fermentation the contents of the jars were examined visually and scored for colour. Then each jar was opened and content the scored for aroma. The subjective scores on a scale of 1, 2, 3 and 4 are described in Table 2. Three independent recorders assessed and scored the silages. The pH of the resultant silage was recorded and materials oven dried at 60°C for 2 days. Five - gram samples were taken from the dried, bulked replicate silages for chemical analysis.

Table 2. Description of colour and aroma scores used in assessing the ensiling characteristics of columbus grass (Sorghum alnum) silages.

Score	Description	
	Colour	Aroma
1	Dark/Deep brown	Putrid or rancid
2	Light brown	Pleasant
3	Pale yellow	Sweet
4	Yellowish green	Very sweet

3.5 Chemical Analysis

Dried silage samples of the five maturity stages were ground to pass through 1mm screen in Christy & Norris laboratory mill. The ground silages were assayed for the nutritive value indices including crude protein (CP), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF), calcium (Ca), phosphorus (P), magnesium (Mg), potassium (K), sodium (Na), manganese (Mn), iron (Fe), copper (Cu), total carotene, and hydrocyanic acid (HCN).

Crude protein was determined by Kjeldhal nitrogen analysis (AOAC, 1975) from which it was calculated as $6.25 \times \% \text{ N}$. Similarly, the ash content and carotene were determined using the methods described by AOAC (1975). Neutral detergent fibre, ADF, hemicellulose and cellulose were determined according to procedures outlined by Goering and van Soest (1970). The minerals were measured by the method of wet digestion while hydrocyanic acid was determined by the method described by Cooke (1978) and Ikediobi *et al.* (1980).

3.6 Statistical Analysis.

Analysis of variance and Duncan's multiple range test were performed to test differences. Linear correlation coefficients (Snedecor and Cochran, 1967) were examined between stage of maturity (as age of pasture) and nutritive value indices of silage to determine trends and magnitude of such relationships. Similarly relations among forage characteristics at ensilage and silage nutritive value indices were determined.

CHAPTER FOUR

RESULTS

4.1 Forage Physical Features At Ensilage

Some of the physical characteristics describing the pasture or forage at ensilage are presented in Table 3. Columbus grass (S. alnum) was found to be a prolific, fast growing perennial fodder crop capable of producing adequate amounts of forage for in situ grazing or ensiling within the season/year of establishment. Fifty days after planting, the pasturage was in its late vegetative stage and had 10% bloom with appreciable yield of 1.3 tDM/ha. At this stage the forage had 85% moisture and 46% leaf content. Thereafter, leaf and moisture contents declined while bloom/inflorescence number and fodder yield increased untill senescence/full maturity at the end of the rainy season. At maturity in the hard dough stage (i.e 90 days post-planting) the moisture and leaf contents of the forage had declined to 55% and 26%, respectively. Within the same period the inflorescence content was 95% while fodder yield had attained 8.4 tDM/ha. The data indicate a mean daily increase in fodder yield of 177.6kg DM/ha between the 50th and 90th day following planting.

Table 3 Descriptive features of columbus grass (*Sorghum alnum*) forage used for silage at various stages of development

Pasture	Stage	Bloom+	Leafiness++	Moisture	Yield
			Percent		(kg DM/ha)
Vegetative	(50)+++	10.3	45.9	85.1	1294.0
Boot	(60)	47.4	41.0	76.0	3600.0
Milk	(70)	69.7	31.7	69.6	4864.0
Soft dough	(80)	81.6	28.3	62.0	6840.0
Hard dough	(90)	95.1	25.6	54.6	8399.0

- + Number of boot/inflorescence per total culm count
 ++ Weight: weight ratio
 +++ Age of pasture in days post-planting

4.2 Silage Characteristics

4.2.1 **Colorimetric and aromatic property:** Table 4 indicates the visual and aromatic characteristics of the silages as well as their pH and HCN contents. Colour and aroma scores as well as pH values are demonstrative of silages of the excellent qualities. There were no significant differences in the properties regardless of phenological stage. However, based on the pH values as well the colour and aroma scores, silages made at boot and milk stages would be more readily acceptable. Compaction with forages of the later stages was found as a physical problem in the laboratory silos used.

4.2.2 **pH:** The pH values of the silages made at the five stages of forage growth are shown in table 4. No significant differences ($P > 0.05$) were found in the pH values of the silages made between the vegetative, soft and hard dough stages. Ensilage is essentially controlled fermentation to favour degradation of soluble carbohydrates to lactic acid. The resultant pH values (4.55 to 4.06) indicate fairly acidic silage with desirable qualities in this respect.

4.2.3 **Hydrocyanic acid:** Determining HCN content of forage is an important aspect in evaluating feeding quality particularly in use of sorghum forages in livestock production. The values were comparatively low and varied from 183.1 to 244.2 mg/kg. There are no significant differences ($P>0.05$) in HCN contents of forages ensiled at early or late stages of development, although in absolute values forages in the vegetative/boot stage contained higher HCN than those at later stages.

4.2.4 **Carotene:** The carotene content of the silages is shown in Table 5. The composition was high for silages of the forage in the vegetative stage but fell when ensilage was delayed to the dough stages. The figures fell from 390.4mg/kg in the vegetative to 35.6 mg/kg in the dough stage. The differences were significant for the three earlier stages but none ($P>0.05$) in carotene content of silages made between milk and hard dough stage of forage growth

Table 4. Colorimetric, aromatic, pH and HCN properties of silages of columbus grass (*Sorghum alnum*) forage harvested at five stages of development.

Forage Phenological Stage	+SCORES		pH	++HCN (mg/kg)
	Colour ^a	Aroma ^b		
Vegetative	ND	ND	ND	218.2
Boot	4.0	4.0	4.06	244.2
Milk	4.0	3.5	4.16	210.1
Soft dough	4.0	3.5	4.55	183.1
Hard dough	4.0	3.0	4.43	210.4
Mean	4.0	3.5	4.30	213.2

- + Score on scale of 1 - 4 defined as
(a) Colour: dark/deep brown to yellowish green.
(b) Aroma: putrid/rancid to very sweet.
++ Hydrocyanic (mg/kg sample).
ND = Not determined.

4.2.5 **Nutrient constituents:** Table 5 presents data on nutrient constituents of the forage ensiled at five stages of development. There were no significant differences in NDF content of silages made at various stages of development. Significant differences ($P < 0.05$) were found in moisture, CP, EE, ADF, Ash, and carotene contents of silage of the forage ensiled up to the milk stages of maturity after which no significant differences were found in the parameters examined. Comparatively, CP, EE, ash and carotene were highest in the vegetative and lowest at the hard dough stage of development. With the exception of ADF, the nutritive value parameters declined with stage of maturity.

Table 5 Nutritive value indices of silage of columbus grass (*Sorghum alnum*) forage ensiled at five stages of development.

Mean	Vegetative		Boot	Milk	Soft dough	Hard dough
	(50)	(60)	(70)	(80)	(90)	
Moisture %	ND	75.1 ^a	65.7 ^b	54.4 ^b	55.9 ^b	62.8
CP %	14.7 ^a	8.8 ^b	8.1 ^b	7.0 ^b	6.4 ^b	9.0
EE %	7.7 ^a	6.2 ^b	5.6 ^b	6.0 ^b	5.3 ^b	6.2
NDF %	77.9	72.6	75.5	78.8	75.3	76.0
ADF %	38.8 ^c	49.5 ^a	45.1 ^b	45.7 ^b	43.9 ^b	44.6
Ash %	8.5 ^a	7.8 ^b	6.2 ^c	5.9 ^c	5.3 ^c	6.8
Carotene (mg/kg)	390.4 ^a	133.6 ^b	40.3 ^c	25.2 ^d	35.6 ^c	125.0

ND - Not determined

Means in columns with different letter are significantly different at 5% level

4.2.6 **Mineral Composition:** Table 6 presents the mineral content of the silages. There was no significant difference ($P > 0.05$) in Ca or Mg content of the silages. There were however significant differences ($P < 0.05$) in N, P, K, Na, Mn, Fe and Cu contents of the silages up to the milk stage beyond which no significant differences were found. With the exception of N, P, K, Na and Fe, there were no consistent trends in the

mineral composition of silages with forage stage of maturity at ensilage. The decline in the mineral content of the silage of the vegetative (at 50 days post-planting) to the hard dough forage (at 90 days post planting) were: 2.35 - 1.03%N, 0.21 - 0.12%P, 3.12 - 1.85%K, 0.13 - 0.08%Na and 1625.2 - 360.7ppm Fe. The variations in contents of Ca, Mg, Mn and Cu were not consistent.

Table 6 Mineral composition of silages of columbus grass (*Sorghum alatum*) forage harvested at five stages of development.

	Vegetative (50)	Boot (60)	Milk (70)	Soft dough (80)	Hard dough (90)	Mean
N %	2.35 ^a	1.41 ^b	1.30 ^b	1.12 ^c	1.03 ^c	1.44
Ca %	0.28 ^b	0.49 ^a	0.52 ^a	0.23 ^b	0.58 ^a	0.42
P %	0.21 ^a	0.19 ^a	0.16 ^b	0.14 ^c	0.12 ^c	0.16
Mg %	0.26	0.19	0.15	0.20	0.21	0.21
K %	3.12 ^a	3.75 ^a	2.29 ^b	1.92 ^b	1.85 ^b	2.59
Na %	0.11 ^a	0.13 ^a	0.10 ^b	0.08 ^b	0.09 ^b	0.10
Mn ppm	49.63 ^a	45.80 ^a	41.70 ^a	45.66 ^a	26.73 ^b	41.90
Fe ppm	1625.2 ^a	1076.6 ^b	469.0 ^c	435.6 ^c	360.7 ^c	793.4
Cu ppm	9.6 ^b	13.2 ^a	10.4 ^b	9.6 ^b	10.0 ^b	10.55

+ Figures in parenthesis signify pasture age in days after planting.

Means in columns with different letters are significantly different at 5% level.
(P<0.05)

4.3 Effect of Forage Physiological Stage of Maturity on Silage Characteristics

Table 7 indicates the relationship (as defined by linear regression coefficients) between age of forage (in days after-planting) with components of pasture and silage value as livestock feed. Characteristics of forage at ensilage (leaf and moisture content) and nutrient characteristics of the resultant silage (moisture, CP, EE, ash, carotene and HCN) were negatively related to forage stage of maturity. The relations

between bloom content of forage at ensilage and the resultant silage pH (NDF and ADF) were positive. However, the relations were only significant ($P < 0.05$) for inflorescence, leaf and moisture contents of the forage at ensilage. For the ensiled forage the relations were significant for moisture, CP and ash content.

Table 7 Regression of forage physical content (%) at ensilage and nutrient components of silage (%) columbus grass (Sorghum alnum) on age of pasture X, days post planting), using the model $Y = a + b X$

Characteristics	r- value	Intercept	Slope
<u>Forage Before Ensilage:</u>			
Leaf	-0.977**	71.81	-0.533
Moisture	-0.989**	121.960	-0.750
Bloom	0.970**	81.84	2.038
<u>Silage:</u>			
Moisture	-0.925*	114.585	-0.691
Crude protein	-0.868*	21.584	-0.179
Ether Extract	-0.846	9.688	-0.051
NDF	0.058	75.420	0.009
ADF	0.264	40.069	0.064
Ash	-0.965**	12.390	-0.080
pH	0.141	56.865	3.990
Carotene +++	-0.779	6495.562	-7.379
HCN+++	-0.555	266.892	-0.767

* Significant ($P < 0.05$)
 ** Significant ($P < 0.01$)
 +++ Composition in mg/kg sample

4.4 Effect of Forage Characteristics at Ensilage on Nutrient Composition of silage

Table 8 shows the linear relationship between forage physical characteristics at ensilage and the nutrient quality parameters of the corresponding silage. Leafiness and moisture content of the forage were positively correlated with CP, EE, ash, carotene and HCN, but negatively correlated with NDF and pH of the silages. The relations were significant for leaf vs CP, EE, and ash. Moisture content was significantly related to EE. With the exception of bloom percentage vs NDF and pH, the relations of bloom content with other silage quality parameters were negative. The relations bloom vs CP, EE, ash and carotene were significant (Table 8).

Table 8 Relationship between forage characteristics at ensilage and silage nutrient constitutions of columbus grass (*S. aluum*).

Silage Nutrient Constituents	Forage Constitution		
	Leaf (%)	Moisture (%)	Bloom (%)
CP (%)	0.888*	0.847	-0.960**
EE (%)	0.874*	0.867*	-0.940*
NDF (%)	-0.121	-0.027	-0.064
ADF (%)	-0.272	-0.035	0.449
Ash (%)	0.998**	0.132	-0.972**
pH	-0.416	-0.105	0.284
Carotene (mg/kg)	0.847	0.798	-0.906*
HCN (mg/kg)	0.635	0.527	-0.488

* Significant (P<0.05).

** Significant (P<0.01).

4.5 Relationship Among Silage Nutrient Constituents

Table 9 presents correlation matrix of the relationships among the various nutritive value indices of the forage sorghum silage. The data indicate few of the relations (moisture vs CP, ADF, ash and HCN; CP vs EE, ash, carotene; and EE vs

carotene) are statistically significant. Crude protein is positively and highly correlated ($P < 0.01$) with moisture, EE and carotene. Similarly, the relations moisture vs ADF, and EE vs carotene were significant (Table 9), the latter positively and the former negatively related.

Table 9 Relationship among nutrient constituents in columbus grass (Sorghum alnum) silage.

	MOS .	CP	EE	NDF	ADF	Ash	pH	CAR	HCN
MOS	-	-	-	-	-	-	-	-	-
CP	0.949***	-	-	-	-	-	-	-	-
EE	0.525	0.960***	-	-	-	-	-	-	-
NDF	0.525	0.253	0.359	-	-	-	-	-	-
ADF	-0.984**	-0.691	0.691	0.228	-	-	-	-	-
Ash	0.927*	0.875*	-0.117	-0.229	-0.259	-	-	-	-
pH	0.260	-0.094	-0.467	0.415	-0.607	-0.506	-	-	-
CAR	0.743	0.968**	0.936*	0.193	-0.699	0.848	0.757	-	-
HCN	0.891*	0.326	0.226	-0.826	0.269	0.639	0.639	0.488	0.382

Definations:

MOS = Moisture, CP = crude protein, EE = ether extract,
 NDF = Neutral detergent fiber, ADF = acid detergent fiber,
 CAR = Carotene, and HCN = hydrocyanic acid

*** Significant ($P < 0.001$).

** Significant ($P < 0.01$).

CHAPTER FIVE DISCUSSION

5.1 Forage Physical Form

In considering the suitability of a plant species as silage material, yield of forage per unit area of land, nutritional quality of the forage at ensilage and the resultant silage are important factors. The results of this study, in support of previous work by Muhammad (1993) on columbus grass (Sorghum alnum) as a hay crop, demonstrated the high potential of the grass for use in intensive livestock production because of its high growth rate and yield of fodder within the year of its establishment. Fodder production of 1.30 to 8.40t DM/ha (Table 3) between the 50th and 90th day of establishment is remarkable. At comparable ages of pasture development, these yields are relatively higher than those reported for conventional fodder grasses grown in Nigeria for hay or silage production including such species as Andropogon gayanus (Haggar 1970, 1975), Pennisetum purpureum (Akinola, 1982), and Brachiaria decumbens (Okeagu *et al.*, 1989). It compares well with forage crops grown with supplementary irrigation (Akinola, 1975, Ariba 1987, Kallah and Mzamane, 1984, and de Leeuw, 1972). The yield of pasture obtained in this study also compares well with maize/cow pea and grain sorghum/mucuna crop mixtures recommended for silage production in Northern Nigeria (Thorpe, 1964). The increase in DM yield and bloom content, and the decline in leaf and

moisture content shown in Table 3 as well as the regression coefficient agree with growth curves of forage and cereal crops grown in the same agro-ecological zone (Haggar 1970 and Goldsworthy 1970).

The perennial habit and rapid growth of Sorghum almum, capable of producing a daily DM increment of 177.6kg/ha between the 50th and 90th day of planting make it a suitable candidate for conserved fodder production in the rainy season. It is possible to harvest and ensile the forage material during the wet growing season while allowing for sufficient regrowth that may be used in hay production or in situ grazing within the same year of establishment.

5.2 Silage Characteristics

Data in Table 4 indicate high scores for both colour and aroma, and fairly acid pH values. These results suggest that satisfactory silages have been produced. The pH values, though slightly higher than those recommended by Catchpoole and Henzell (1971) for well preserved grass silages, compare favourably with the pH values of the maize, grain sorghum + velvet bean and maize + cowpea crop or crop combinations recommended earlier (Miller et al., 1963 and Thorpe, 1964) and still in use for silage making in Northern Nigeria. The HCN levels for the silages shown in Table 4 are nearly half the levels reported by Muhammad (1993) for the non-ensiled

forage with mean levels of 213.2 vs 392.0mg/kg. The data suggest that ensilage could have a depressing effect on the HCN content of the forage sorghum. The HCN values varying between 183 to 244 mg/kg are well below the range of 500 to 750mg/kg defined by Bogdan (1977) and Haskin et al. (1987) as dangerous to livestock on sorghum forage diets.

The nutritive value parameters and their relations with stage of maturity as depicted in Table 5, 6 and 7 are consistent with findings in the literature for crop silages (e.g Black et al. 1980; Browning and Lusk, 1967; Danley and Vetter, 1973; and Miller et al. 1963). The silage nutrient constituents (CP, minerals and carotene) were depressed as the crop matured. Crude protein levels of silages declined from 14.7% in the vegetative to 6.4% in hard-dough forage. The CP and EE levels of the silages are lower compared to levels reported by Muhammad (1993) for the non-ensiled forage. These findings are contrary to the results of Black et al. (1980) which showed the resultant silages being higher in CP and EE than the corresponding non-ensiled forages.

Carotene, long recognized as important in the nutrition of cattle grazing on savanna grassland (Miller 1960, 1961, and Miller and Iduma, 1967) declined from 390.4 to 35.6mg/kg. A similar fall in carotene level was found in Andropogon gayanus fodder from 49.0mg/kg in late August to 12.3mg/kg in the first week of October (Haggar 1970). In practical terms

the carotene requirements for cattle and sheep vary between 4.0 to 50.0mg/kg, and 0.2 to 10.0mg/kg of dry ration, respectively (Church, 1980). Thus, the carotene levels found in the silages of this study (Table 5) are apparently adequate in satisfying the requirements of sheep and cattle.

Phosphorus (P) and sodium (Na) both important in the nutrition of cattle grazing native rangeland forages of the Northern Guinea Savanna (Adamu et al., 1993) declined with maturity. The range in values were 0.21 to 0.12% for P and 0.13 to 0.08% for Na. Mean values for mineral composition (Table 6) indicate that the resultant silage, compared to those for the non-ensiled forage reported by Muhammad (1993), has higher contents of Ca, K, Na, Fe and Cu, and lower contents of N and P. The contents of Mg and Mn were similar in both the silage and the non-ensiled forage. Based on the recommendations of McDowell (1985) for ruminant production in warm climates the mineral composition of the silages in this study is inadequate for P, borderline for Na, and adequate for N, Ca, Mg, Mn, Fe, and Cu. The potential deficiencies of P and Na in the silages is consistent with findings of Muhammad (1993) in the non-ensiled Sorghum alnum forage. The potential deficiencies of P and Na found in the Sorghum alnum forage and silage is in agreement with what had been found by Kapu (1974) and Tanko (1993) on native rangeland forages of the Northern Guinea Savanna. The grazing trial of Adamu et al. (1993) had demonstrated the beneficial effects of P and

Na supplementation on weight gain and conception rates of heifer.

The relationships between forage physical form at ensilage and the nutritive value of resultant silage (Table 8) suggest that leaf and moisture content of the forage at ensilage are positive indicators of high quality silage in terms of CP, EE and carotene, while the relations between nutritive value of resultant silage and bloom content suggest otherwise.

The high correlations among nutrient components within silage indicate that moisture content may provide a simple index of determining the value of the silage in terms of CP and ADF, Likewise, the CP content may be indicative of the carotene content of the silage. Further investigations to examine such relations would be desirable.

CHAPTER SIX
SUMMARY AND CONCLUSIONS

6.1 Summary:

A study was conducted on field grown columbus grass (Sorghum alnum) at the National Animal Production Research Institute (NAPRI), Shika, Ahmadu Bello University, Zaria, Nigeria during the rainy season of 1992. The objective of the trial was to examine the ensiling characteristics of the grass, and also determine the influence of pasture stage of maturity and physical composition of forage at ensilage on the nutritive value of the resultant silages. Forage sown on 30th July 1992 was harvested at pasture stages of 50, 60, 70, 80, and 90 days post-planting and ensiled in laboratory silos. Following an incubation of 21 days the resultant silage was analysed for ensiling characteristics and nutritive value indices.

The forages at ensilage declined in contents of moisture (85.0 to 56.0%) and degree of leafiness (46.0 to 26.0%) with advancing stage of maturity. Bloom content and fodder yield rose between the 50th and 90th day after planting. The range in values were: bloom, 10.3 - 95.1%; and yield, 1.30 - 8.40 ton DM/ha. Fodder accumulation was rapid with average daily yield increment of about 177.0kgDM/ha.

Forage materials at all stages of maturity resulted in satisfactory silages with moderate acidic pH values (4.6 to 4.1) as well as favourable aroma and colour scores. HCN content was comparatively low relative to the amounts in non-ensiled forage and declined with maturity from 244.0 to 183.0 mg/kg. Plant factors (e.g CP, EE and carotene) favouring forage digestibility declined with stage of maturity while plant cell wall structural constituents (NDF and ADF) showed positive relations. Carotene content declined from 390.4 to 35.6mg/kg. Mineral composition of silage made during the late vegetative to hard dough stages exhibited variations within the ranges of: 1.03 - 2.35%N, 0.23 - 0.58%Ca, 0.12 - 0.21%P, 0.15 - 0.26% Mg, 1.85 - 3.75K, 0.08 - 0.13%Na, 26.7 - 49.6ppm Mn, 360.7 - 1625.2ppm Fe and 9.6 - 13.2ppm Cu.

Significant linear relations were found between forage physical characteristics at ensilage and some nutrient constituents of the resultant silage. Positive correlations were found between leaf content vs CP, EE, and ash content, while negative correlations were found between bloom content vs CP, EE, ash and carotene content. Within the resultant silage the relations of moisture content vs CP, ADF, ash and HCN; CP vs EE, ash, carotene and HCN; and EE vs ash and carotene were significant.

The silages in the study consolidated well and the fermentation was complete with moderately acid pH values. Based on ruminant

nutritional standards the mineral composition of the silages were apparently sufficient in supplying the requirement of Ca, Mg, Mn, Fe, Cu and Carotene for production. The silages were deficient in phosphorus and borderline in sodium concentrations. Furthermore, it may be beneficial to supplement protein on silages made after the milk stage.

6.2 Conclusion:

Results reported in this study further confirm the rapid growth rate and high fodder accumulation of Sorghum alnum. Satisfactory silages were made from forage materials harvested at the late vegetative to hard dough stages. The materials consolidated well and the fermentation was complete resulting in moderately acidic pH values. Nutritive value indices favouring quality and nutrient availability declined with stage of maturity. As a compromise between fodder yield and nutritional quality, the soft dough stage (ca 80 days post-planting) is recommended as the optimum stage for harvesting the fodder for ensilage. Such silages may, relative to recommended nutritional standards, contain insufficient amounts of N, P and Na to satisfy the nutritional requirements of ruminants for production. Supplementation of these minerals would be essential if production is the objective of management. Animal studies involving feeding trials are however advocated so as to elucidate further and define the limits of S. alnum silage in ruminant feeding systems.

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