



Physical Properties of Ensiled Maize and Legumes Stover and Acceptability by West African Dwarf goats

*Amuda A.J. and Tanko N.

Department of Animal Production and Health, Federal University Wukari, P.M.B 1020, Taraba State

Abstract

Maize stover is a left-over of maize plant in the field after harvesting the grains. It can serve as potential feed for ruminants if it is well processed and preserved especially during the dry season when there is scarcity of feed. Consequently, a study was carried out to investigate the physical properties of ensiled maize and legumes stover and acceptability by West African Dwarf (WAD) goats. Maize stover were ensiled for 64 days using different legumes stover (bambaranut, groundnut, soya bean and cajanus cajan stover) at ratio 4:1 (i.e 80% maize stover + 20% legumes stover) to obtain the following silages: Maize Stover only (control) Maize stover and bambaranut stover (MSBS), Maize stover and groundnut stover (MSGS), Maize stover and soya bean stover (MSSS) and Maize stover and cajanus cajan stover (MSCS). Seven WAD goats were used to assess the silage acceptability using coefficient of preference (CoP) procedure. The pH, colour, texture, moisture content (MC) and dry matter (DM) were determined in laboratory using standard techniques. The bright light green and, greenish-brown colour, firm texture, vinegar like odour observed for this study indicate that the silages were well prepared and preserved. The temperature, pH, MC and DM values ranged from 26.85 – 28.50°C, 3.80 – 3.89, 55.11– 62.01% and 37.99 – 44.89%, respectively. The pH, MC and DM were similar across the treatments, however temperature of control silage (MS only) was significantly ($P<0.05$) different from ensiled maize stover with cajanus cajan stover (MSCS). Acceptability study of the silages showed that MSGS, MSCS and MS (control) were preferred to other silage types. However, mean daily consumption (MDCg/day) suggests that with time goats will accept the other silage types. The results of this work showed that ensiled maize stover with legumes stover can be utilized by goats if it is well prepared and preserved.

Keywords: Maize stover, legumes stover, acceptability, coefficient, goats.

Introduction

Food sector needs to secure nutrition for the one billion people who are undernourished and meet demand from an increasingly affluent urban population in newly developed and emerging economies (Delaval 2012). The increasing human population posed serious challenges to livestock production out of which are; the competitions arising from the same sources of food and the increasing demand for animal proteins that human body cannot synthesized. To overcome these challenges, there is needs to utilize crop residues such as maize stover and legumes

stover in ruminants feed in order to reduce competition between man and animal. Maize stover left on most maize farm after harvests are wasted without maximizing their value to animals which will in turn mean gain to the famers. Crop residues constitute an important feed resource for animals especially in the dry season. Cereals straw and stover, legume crops straw and hulls, sugar cane tops, cassava leaves and sweet potato vines are left in the field or harvested for livestock feeding. However, these crop residues are generally poorly utilized as animal feed each year because small-scale farmers lack the

technical knowledge on how best to use them (Syomiti, 2003,). According to Chaudhary *et al* (2012) maize stover consists of the leaves and stalks of maize plants left in a field after harvest and consists of the residue: stalk; the leaf, husk, and cob remaining in the field following the harvest of cereal grain. It makes up about half of the yield of a crop. Maize stover is abundance agricultural product in areas having large acreage under maize cultivation. Stover is widely used as the major source of animal feed in many countries particularly in the regions having plenty of maize production. With the increasing production and productivity of maize, the maize stover is available in large quantity. Corn stover amounts would range from 3-4 tons per acre. Maize Stover can successfully be incorporated in ruminant rations and that such rations have relatively high digestibility. However, the nutritional quality of maize stover is poor. It is made up of cellulose, hemicelluloses, lignin etc (Chaudhary *et al* 2012). This is often improved with leguminous haulms to meet up the nutrient requirement of animals feeding on it. To meet out the needs of the ever increasing livestock population the production as well productivity of fodder is to be increased. However, the increasing cultivation of cereal and cash crops has, in fact, contributed towards a decline in land mass under fodder cultivation (Chaudhary *et al* 2012). Consequently, there is a great constraints of livestock feeds and fodder availability, as land for fodder production has been marginalized. For this reason, there is need for preservation and storage in proper ways to balance up the available feeds and fodder.

Silage is the product from a series of processes by which cut forage of high moisture content is fermented to produce a stable feed which resists further breakdown in anaerobic storage. The objective is to retain or augment the nutrients present in

the original forage and deliver a silage accepted by livestock; this is usually attained through an anaerobic fermentation dominated by lactic acid bacteria (Chaudhary *et al.*, 2012). In the tropics, particularly the semi-arid tropical regions, where the major constraint of livestock production is the shortage of fodder during the dry season, conservation through ensilage of forage produced during the rainy season is likely to be the practice adopted by most small holder livestock owners, particularly those in dairy or beef production. However, tropical grasses is not natural ensilage material, largely because at cutting, they have a low content of water-soluble carbohydrates, which are essential to successful ensilage. However, the levels of fermentable carbohydrates can be improved through various treatments including mixing legumes with cereal crops (Phiri *et al*, 2007). Ensiling is a popular and efficient method of preserving maize stover and legumes stover for ruminants feed. Thus, the research was carried out to assess the quality characteristics of ensiled maize stover mixed with legumes stovers and acceptability by West African Dwarf goats.

Materials and Methods

Experimental Site

The study was carried out at Teaching and Research Farm of Federal University Wukari, Taraba state. Wukari lies between latitude 7°51'N to 7°85'N and longitude 9°46'E to 9°78'E of the Greenwich meridian. The mean annual rainfall value ranges from 1000 - 1500 mm. The unset of the raining season is usually around April while the offset period is October. The mean maximum temperature is experienced around April at about 40°C while the mean minimum temperature occurs between the period of December and February at about 20°C (Oyatayo *et al* 2015, Taraba State Government Diary, 2008).

Harvesting of Maize Stover and Silage Making

Freshly harvested green maize stover and legumes stover were obtained from the University Teaching and Research farm Federal University Wukari. The maize and legumes plots were practically cultivated for the study in the month of August. However both maize and legumes were planted separately. Harvesting was done in the month of November. Harvested maize stovers with four different legumes stover (Groundnut stover, Soya bean stover, Bambaranut stover and *Cajanus cajan* top/stover) were chopped into 2-5 cm length (for easy compaction) with cutlass. The chopped materials were wilted under shade for 12 hours on the polythene sheet in order to reduce moisture content. The samples were weighed, using weighing scale and each silage type weighed 6.25kg. Maize stover (MS) and each legumes stover (LS) were mixed at the ratio of 4:1 (i.e. 1kg MS + 0.25kg LS). The samples were thoroughly mixed and divided into five treatments:

Treatment A = Maize stover only (control), Treatment B = Maize stover + Groundnut stover,

Treatment C = Maize stover + Soybean stover, Treatment D = Maize Stover + Bambaranut and Treatment E = Maize stover + *Cajanus cajan* stover.

5kg of Maize stover was ensiled with 1.25kg of each legume stover. Each silage type was ensiled in polythene bags silo, each capable of holding 6.25Kg of wilted ensiled materials. Each polythene bag was placed inside a 100 litres capacity plastic container for reinforcement and ease of fermentation. Ensiling was done by rapid compaction of the materials (to eliminate air) into the silos. Sealing of the silos was done by placing 15 Kg sand bag on top of the polythene bags after tying carefully and firmly. The treatments were replicated four times in a Complete Randomised Design

(CRD). The fermentation period was 64 days.

Evaluation of Quality Characteristic of the silages

Silages were open after 64 days of fermentation period for quality assessment. The quality characteristics assessed were odour, mouldness, texture and colour. Silage colour was assessed by visual observation and colour chart. A 5 - man panel assessed the odour and texture of the silage. This step was taken to guide against a bias attitude of one – man assessor since the involved physical attributes are on the nominal scale rather than ordinal. The temperature of silage was taken immediately it was opened by inserting a laboratory thermometer inside the silage mass and kept for five minutes before taking the reading. Sub-samples from different points and depths were later taken and mixed together for dry matter determination by oven drying at 65°C. The pH of the silage was determined by taking 25g of sample from each treatment mixed with 100mls of distilled water in a beaker for 1 hour and agitated for 2 minutes (Babayemi 2009, Falola *et.al*, 2013 and Amuda *et al.*, 2017). Following this, a pH meter glass electrode was then inserted into the supernatant for 1-2 seconds and pH determined following a standard procedure (AOAC, 1995).

Acceptability study

Experimental Site

Acceptability study was carried out at Federal University Wukari Teaching and Research farm, goat unit.

Experimental Animal

A total of seven growing West African Dwarf Goats of average weight of 11±1kg and about a year were used for the study. They were subjected to free choice feeding to evaluate the acceptability of ensiled maize stover with and without legumes

stover (diets A,B,C,D and E) in cafeteria feed preference study (Babayemi *et al.*, 2006). The Animals were housed together in the group pen at goat unit of Federal University Wukari Teaching and Research Farm.

Experimental Diets

The experimental diets were:

A- Maize Stover only (control), Diet B- Maize Stover + Groundnut stover

Diet C- Maize Stover + Soya Bean stover,

Diet D - Maize Stover + Bambaranut stover

Diet E- Maize Stover + *Cajanus cajan* stover

Feeding Experimental Animal

The five silages were introduced on cafeteria basis to animals (goat) in five

different feeding troughs according to Babayemi *et al.*, (2009), so that each animal had free access to each of silages in the trough. The position of the silages in the feeding trough was changed daily to prevent bias by an animal from sticking permanently to trough. The study was carried out for seven days. The intake was measured by deducting the orts or remnant from the amount of the feed offered. Silage preference was determined from the coefficient of preference (CoP) value; calculated from the ratio between intake of each individual silage divided by the average intake of five silage types (Bamikole *et al.*, 2004, Babayemi *et al* 2009).

$$\text{Coefficient of preference (CoP)} = \frac{\text{Intake of individual silage}}{\text{Mean intake of five silage types}}$$

If CoP<1, the material is poorly accepted and when > 1 the material is well accepted. (Karbo *et al.*, 1993, Bamikole *et al.*, 2004).

The experimental design used in this research was Complete Randomized

Design (CRD) and the data collected were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 23 and the significant means were separated by the use of Duncan's Multiple Range Test.

Result and Discussion

Table 1: Physical characteristic of ensiled maize stover with four different legumes stovers

Treatment	Colour	Texture	Odour	Mouldness
A	Bright light green	Firm	Vinegar	Slightly mouldy
B	Bright light green	Firm	Vinegar	Not mouldy
C	Greenish brown	Firm	Vinegar	Not mouldy
D	Greenish brown	Firm	Vinegar	Not mouldy
E	Bright light green	Firm	Vinegar	Slightly mouldy

A = Maize Stover only (control), B = Maize Stover + Groundnut Stover, C = Maize Stover + Soybean Stover D = Maize Stover + Bambara nut Stover, E = Maize Stover + *Cajanus cajan* Stover

Physical Characteristics of Silage

Table 1 shows the physical characteristics of ensiled maize stover with four different legumes stovers. The silages were similar in their physical properties. The bright

light green and greenish brown colour, firm texture, vinegar like odour exhibited by ensiled maize stover with and without legumes (control) are characteristics of a good and well-fermented silage. The smell

of the well-fermented silage is like that of vinegar whereas poorly fermented silage is characterized by foul smelling. In the properly fermented silage, the soluble carbohydrates are converted to lactic acid which is largely responsible for good odour, whereas in the poorly fermented silage, butyric acid is the end product of fermentation which is primarily responsible for the bad or foul smell. Properly prepared silage is recognized from colour. The colour of the well-fermented silage is bright light green or dull yellow whereas that of the poorly fermented silage is olive, blue green or dark brown (Chaudhary *et al.*, 2012). Chemical changes during ensilage process can affect the colour of forages and the fermentation acids can convert chlorophyll

into the brown magnesium-free pigment phacophytin. Good silage usually preserves the original colour of the pasture or forage used to produce it (t'Mannetje, 1999). Consequently the brightly colour expected. The bright light green and greenish brown colour obtained in this study were in order. The colours were closed to the original colour of the ensiled materials which was an indication of good quality silage that was well prepared and preserved (Babayemi, 2009, Falola *et al.*, 2013, Amuda *et al.*, 2017 and 2018). The dry firm texture and vinegar like odour, observed in this study is accepted for good silage as reported by Kung and Shaver cited by Babayemi (2009) and (Chaudhary *et al.*, 2012).

Table 2: Temperature, pH, Moisture and Dry Matter of Ensiled Maize stover with Legumes stover

Parameters	Treatments					SEM
	A	B	C	D	E	
Temperature (°C)	28.50 ^a	27.63 ^{ab}	26.85 ^{ab}	27.70 ^{ab}	27.75 ^b	0.59
pH	3.84	3.81	3.80	3.89	3.86	0.04
Moisture (%)	59.51	55.11	61.56	62.01	57.79	2.84
Dry Matter (%)	40.50	44.89	38.44	37.99	43.96	3.15

a,b = means on the same row with different superscripts are significantly ($P < 0.05$) different.

A = Maize stover only (control), B = Maize Stover + Groundnut stover, C = Maize stover + Soya bean stover, D = Maize + Bambaranut stover, E = Maize Stover + *Cajanus cajan* stover, SEM = Standard Error of Mean

Presented in Table 2 is temperature (°C), pH, moisture content (MC %) and dry matter (DM %) of the silages. Temperature of the silages varied significantly ($P < 0.05$) among the treatments. The temperature of fermented silage or forage varying from 27-38°C was presumed to produce excellent silage (Muck, 1996). The temperature ranged values of 26.85-28.50°C obtained for all the silage was within the normal range of well fermented forage. Furthermore, temperature is one of the essential factors affecting silage colour. The lower the temperature during ensiling, probably the less will be the colour change (Adesogan and Newman,

2010). If the temperature obtained for the present silage was above 40°C or 45-60°C, they would have become yellowish brown to brown dark colour with tobacco-type smell due to caramelization of sugars in the silages (McDonald *et al.*; 1995, Babayemi; 2009). However, in this study, the range (26.85-28.50°C) obtained during fermentation period of 64 days was in agreement with and within the temperature of 27-38°C reported by (Muck, 1996, Amuda *et al.*, 2017). pH is one of the simplest and quickest ways of evaluating silage quality.

The lower the pH, the better preserved and more stable is the silage. However, pH

may be influenced by the moisture content and the buffering capacity of the original materials. Silage that have been properly fermented will have lower pH (that is acidic) than the original forage. The pH value of good silage below 4.1 has been considered as an index of good quality (Harrison *et al.*, 1995). Similarly result reported by Eweedah (2005) indicated that good quality silage made from corn stover has pH value of 4.1. The pH value of 3.80 - 3.89 of silages is slightly lower than 4.1 reported by Eweedah (2005), 4.5-5.5 by Manesses *et al.*, (2007), 4.2 -5.0 by Babayemi (2009) and Kung and Shaver (2002). However, the pH values for both control (ensiled maize stover only) and ensiled maize stover with legumes stovers in this study were in agreement with 3.48 – 3.7 and 3.44 – 3.52 reported by Amuda *et al.*, (2017 and 2018) for well preserved and good quality silage. The low pH range values of silages reported in this study is an indication of proper fermentation and good qualities. The low pH values obtained in this work coupled with vinegar odour indicates that lactic acid is the dominant acid of the silage. The observation made here is further evidence that maize stover can be ensiled with or without legumes stover and produce good silage. This is

because the stem is rich in water soluble carbohydrate (Natural sugar) and ferment more easily, but the majority of other forages will require one additive or combination of additives for easy fermentation (Bolsen *et al.*, 1996, Amuda *et al.*, 2017 and 2018).

The dry matter (DM %) percentage composition and moisture content of the silages were similar across the treatments and the values ranged from 37.99 - 44.89%, 55.11 - 62.7%, respectively. Dry matter of silages with or without legume stovers was higher than 31.1 – 35.3% obtained by Amuda *et al.*, (2017), 30.65-35.26% reported by FAO (2010), 37.02% obtained by Elkohly *et al.* (2009) and a range of 21.2-28.46% obtained by Moran (2005), Ashbell and Weinberg (2002). The differences could be as a result of difference in legume stovers used, season, wilting and age of forage used. The values of DM obtained in this study indicate that silage types were well preserved. The moisture content of the silages was similar to ranged value (59.35 – 68.58%) reported by Amuda *et al.*, (2018). The ranged value obtained fall within normal moisture content of good quality silage.

Table 3: Dry matter intake and coefficient preference of WAD goat fed ensiled maize stover

Silage type	MDC of Animals (g/DM)	CoP	Ranking
A	390.99	1.0	Good
B	425.49	1.08	Good
C	373.66	0.95	Poor
D	359.47	0.92	Poor
E	414.27	1.06	Good

MDC = Mean Daily Consumption of Animals (g/DM), CoP = Coefficient of Preference

A = Maize Stover only (control), B = Maize Stover + Groundnut Stover, C = Maize Stover + Soybean

D = Maize Stover + Bambara nut Stover, E= Maize Stover + *Cajanus cajan* Stover

Table 3 presents coefficient of preference (CoP) of ensiled maize stover with four different legumes stovers fed to WAD

goats. In this study, the mean dry matter and coefficient of preference (CoP) by goats placed on ensiled maize stover (MS)

with and without legumes are indicated. The CoP varied from 0.92 to 1.08 and DM/day consumption ranged from 359.47 to 425.49g with the order of preference as; MSGNS > MSCS > MS > MSSS > MSBN. In order words, MS (Control), MSGNS and MSCS silages with CoP ranging from unity and were accepted or preferred. Conversely, MSBNS and MSSS silages with CoP values of 0.92 and 0.95 each were not accepted (Karbo *et al.*, 1993, Bamikole *et al.*, 2004). Acceptability or free choice intake attributes of a feed connotes the actual response of an animal to a particular feed and the possible visual effects of the feed to the animal. In recent times, cafeteria techniques have been used to assess the acceptability of some forage (Bamikole *et al.*, 2004, Babayemi, 2007 and Amuda *et al.*, 2018). The forage preference on cafeteria basis revealed that ensiled MSGNS, MSCS and MS were consumed most with dry matter intakes of 425.49, 414.27 and 390.99g/DM/day, respectively. Generally, acceptability, seasonal variation and availability are some factors that influenced feed intake by an animal. The factors that may influence acceptability of a forage or feed by small ruminants are plant physical structure, chemical composition, season and age of forages are the most important factors influence preference (Babayemi, 2009 and Van soest, 1994). On the basis of the quantity consumed by the goats, with time the animals will get used to it. Since all the five silage types were accepted numerically, this indicates that the animals had preference for the silages which may

be due to quality and composition of ensiled materials.

Conclusion

The study showed that control silage (ensiled maize stover only) and ensiled maize stover with legumes stover have good quality characteristics suggesting that good silage can be prepared from maize stover with or without legumes stover. Similarly, the study also showed that ensiled maize stover with legumes stover is acceptable to goats, thus the silage can be incorporated in their diet as alternative feed source during the dry season. This will ameliorate the problem of dry season feeding particularly, the livestock smallholder farmers.

Finally, this investigation demonstrated that available maize stover and legumes stover in Nigeria have potential value in ruminants' feedstuffs if properly processed and preserved.

Recommendations

Ensiled maize stover with groundnut and cajanus cajan stovers can be fed to small ruminants during dry season when there is scarcity of forages particularly when the quality and quantity of grasses is low. The best time to harvest maize stover and legumes stover for silage production should be when the leaves are green and nutrients composition is relatively high. This will reduce demand for concentrate supplements in order to meet the protein requirement of the ruminant animals in drying season period.

References

- Adesogan, A. T. and Newman, Y. C. (2010). Silage Harvesting, Storing, and Feeding. SS-AGR-177/AG180: Forage management (Florida Forage Handbook). Pp. 1-7.
- Amuda A.J., Okunlola O.O and Babayemi, O.J. (2018). Quality Characteristics and Chemical Composition of Ensiled Maize Stover with or without Additives. Proceedings of 43rd Annual Conference of the Nigerian Society for Animal Production. Editors: I.C.Okoli,

- L.P.Ogbuewu, O.O.Emenalom and B.O.Esonu. March 18th-22nd 2018 FUT Owerri.
- Amuda A.J, Falola, O.O and Babayemi, O.J (2017). Chemical composition of quality Characteristics of ensiled maize stovers. *Federal University Wukari Trends in Science and Technology Journal* 2(1):195-198.
- A.O.A.C. 1995. The official methods of Analysis. Association of Official Analytical Chemist, 16th Edition, Washinton D.C. pp.69-88.
- Ashbell, G. and Weinberg, Z.G. (2012). Top Silage losses in horizontal Silos. *Can.Agric.Eng.* 34:171-175.
- Babayemi, O. J., Bamikole, M. A. and Omojola, A. B. (2006). Evaluation of the nutritive value and free choice intake of two aquatic weeds (*Neophrolepis biserrata* and *Spirodela ptyrhiza*) by West African dwarf goats. *Tropical and sub-tropical Agro-ecosystem* 6 (1): 15-22
- Babayemi, O. J. (2007). *In vitro* fermentation Characteristics and acceptability by West African dwarf goats of some dry season forages. *African Journal of biotechnology* 6(10): 1260 – 1265
- Babayemi, O.J., (2009). Silage quality, dry matter intake and digestibility by African dwarf Sheep of Guinea grass (*Panicum maximum cv ntchisi*) harvested at 4 and 12 week regrowths. *African Journal of biotechnology* 8: 3988-3989.
- Bamikole, M.A., U.J. Ikhatua, M.T. Ajulo and A.C. Osuji, (2004). Feed utilization potential of West African dwarf goats fed different proportions of *Ficus thonningii* and *Panicum maximum*. Proceedings of the 29th Annual conference of Nigeria society of animal production, Vol., 29, pp: 336 -340.
- Bolsen, K. K., Ashbell, G. and Weinberg, Z. G. (1996). Silage fermentation and silage additives. Review, *Asians-Australian Journal of Animal Science* 9(5): 483-493.
- Chaudhary, D.P, Ashwani, K., Sapna S. Mandhanian, P. Srivastava and R. S. Kumar (2012). Maize as Fodder. An alternative approach, Directorate of Maize Research, Pusa Campus, New Delhi - 110 012, Technical Bulletin. Pp. 17 - 32
- Delaval (2012), XVI International Silage Conference Published by MTT Agri food Research Finland pp
- Duncan (1995). Multiple Range F-test.
- Elkholy, M. E.H., Hassanein, E.I., Soliman, M. H., Wafaa, E., Elgamei, M.F.A and Dohaa, I. (2009). Efficacy of feeding ensiled corn crop Residues to Sheep. *Pakistan Journal of Nutrition* 8(12); 1856-1857.
- Eweedah, U.M. (2005). Evaluation of corn stover Silage and whole corn Silage on growing lambs. Performance. *J. Agric.Res. Tanta Univ.* 31.
- Falola, O.O., Alasa, M.C., and Babayemi, O.J. (2013). Assesement of Silage Quality and Forage Acceptability of Vetiver Grass (*Chrysopogon zizannioides* L. Roberty) Ensiled with Cassava Peels by Wad Goat. *Pakistan Journal of Nutrition* 12(6): 529-533.
- FAO (2010) Food and Agricultural Organisation. Silage making for smallscale Farmers. Retrieved on January 18, 2012 from www.ueexedu/otherAreas/Publication/PDF/FSA-3052pdf.

-
- Harrison, J. H. Blauwiekel, M. R. and Stokes, M. R. (1995). Fermentation and utilization of grass silage. *Journal of dairy Science*. 77: 3209-3235
- Karbo, N. Barnes, P. and Rudat, H. (1993). An evaluation of browse forage preferences by sheep and goat in the Northern savannah zone, Ghana. In: J. Ndikumanaan P. deLeeuw (eds), proceedings of the 2nd African Feed Resource Network (AFRNETA) on sustainable feed production and utilization small holder Livestock enterprises in sub-Saharan African. Harare, Zimbabwe, 107-110.
- Kung, L. and R. Shaver, (2002). Interpretation and use of silage fermentation analyses reports. Dept. of animal and food science, University of Delaware Newark, DE 19717.
- McDonald, P., Edward, R.A. Greenhalgh, J. F. D. and Morgan, C. A. (1995). *Animal Nutrition*. 5th Ed. Longman Scientific and Technical, England.
- Mannetje, L. (1999). Introduction to the conference on silage making in the tropics. In Mannetje, L. 't (Ed.), *Silage Making in the Tropics with Particular Emphasis on Smallholders*. Proceedings of the FAO Electronic Conference on Tropical Silage, FAO Plant Prod. And Protect. Paper 161. 1 Sept. – 15 Dec. 1999. Rome, Italy.
- Manesses, M. D., Megias, J., Madrid, S., Martineztevel, Henandez S. J and Oliva, J., (2007). Evaluation of the photosanitary, fermentative and nutritive characteristic of the silage made from crude artich-oke (Cynarascolymus L) by-products feeding for ruminants. *Small Ruminant Research* 70:2092-296.
- Muck, R.E. (1996) A Lactic Acid Bacterial Strain to Improve Aerobic Stability of Silages. In: 1996 Research Summaries, US Dairy Forage Research Center, Madison, 42-43.
- Oyatayo T. K., Songu A. G., Amos A. G. and Ndabula C (2015). Assessment of heavy metal concentration in hand dug well water from selected land uses in Wukari Town, Taraba state Nigeria. *Journal of Geoscience and Environmental protection* 3: 1-10.
- Phiri, M.S.; Ngongoni, N.T.; Maasdorp, B.V.; Titterton, M.; Mupangwa, J.F.; Sebata, A. (2007), Ensiling characteristics and feeding value of silage made from browse tree legume-maize mixtures. *Tropical and Subtropical Agroecosystems* 7(3):149-156.
- Syomiti, M., M. Wanyoike, R. G. Wahome and J. K. N. Kuria (2003), The status of maize stover utilization as feed for livestock in Kiambu and Thika districts of Kenya: Constraints and opportunities 1 Kenya Agricultural Research Institute (KARI), Muguga South, P.O Box 30148-00100, Nairobi, Kenya 2University of Nairobi; Department of Animal Production P.O Box 29053, Nairobi, Kenya
- Van Soest, P. J. 1994. *Nutritional Ecology of Ruminants*. 2nd Edition. Cornell University Press, USA. Pp. 476.