Pak. J. Bot., 43(6): 2967-2970, 2011.

EFFECT OF MATURITY ON COMPARATIVE NUTRITIVE VALUE AND FERMENTATION CHARACTERISTICS OF MAIZE, SORGHUM AND MILLET SILAGES

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Abstract

This study was conducted to compare nutritional worth of maize (*Zea mays*), sorghum (*Sorghum bicolor*) and millet (*Pennisetum americanum*) silages. These fodders were manually harvested and then preserved in laboratory scale silos at three physiological stages i.e., pre heading (CS1), heading (CS2) and milk stage (CS3). The results showed that the dry matter, neutral detergent fibre, acid detergent fibre, acid detergent lignin and water soluble carbohydrate contents increased ($p<0.05$) in all three fodder silages with advancing age. However, crude protein, total digestible nutrients and metabolizable energy contents decreased ($p<0.05$) in all fodders silages with the advancement of their growth. The water soluble carbohydrates, pH and ammonia nitrogen values of silages prepared from three fodders decreased ($p<0.05$) as the plants advanced in age. However, lactic acid contents in three fodder silages increased ($p<0.05$) with the advancement of age of fodder. Based upon nutritive value and fermentation characteristics, the milk growth stage was the best physiological stage of the three fodder silages.

Introduction

One of the major problems that hinder expansion of ruminant production in Pakistan is the un-availability of good quality fodder in sufficient quantity (Sarwar *et al.,* 2002). In most of the areas of country, the season for active fodder growth is limited by climatic factors. Summer and winter season extremities impose severe clutch in supply of green fodder to livestock and thus adversely affects their productive performance (Rasool *et al.,* 1996).

One of the solutions to overcome the seasonal fodder deficiency is the conservation of surplus fodder during peak fodder growth period. Silage making is one of the best methods for conservation of fodder (Schukking 1994). Silage production is not a common practice among livestock farmers generally in the tropical countries and specifically in Pakistan. Moreover, fermentation characteristics of tropical fodder silages and their feeding values have not been identified (Panditharatne *et al.,* 1986).

Stage of growth is one of the most important factors influencing nutritional quality of fodder silages (Fariani *et al.,* 1994). Sullivan (1973) reported that the nutritive value of a fodder and its silage depended upon the morphological and physiological changes. As the fodder matures, the cytoplasmic portion of the cell reduces and the quantity of protein, lipids, soluble carbohydrates and soluble minerals decrease.

In conserved fodder, the cell contents of (crude protein (CP), ash and lipid) tended to decrease whereas, dry matter (DM) and cell wall contents tended to increase with the advancement of maturity of fodder. St. Pierre *et al.,* (1987) ensiled maize fodder at different vegetative stages of growth (milk, dough, first frost, second frost and fifth frost) and they concluded that second frost (34.1% DM) was optimum stage for making good silage.

In general, other studies suggested that the optimum time to harvest corn for silage making was when starch deposition in kernels was completed (Bal *et al.,* 1997; Harrison *et al.,* 1998). This stage (33-37%DM) is characterized by the appearance of a small black layer on the site where the kernel attaches to the cob. When sorghum was harvested at late-milk, late-dough and hard-grain stages of maturity, higher nutritive values were noticed at late milk stage silages (Sonon & Bolsen, 1996).

The information on nutritional values of local maize, sorghum and millet fodder silages is almost scanty. Therefore, the present study was undertaken to examine the nutritive value of fodder silages and silage characteristics of these silages when fodders are harvested at different stages of growth.

Materials and Methods

Fodders sowing: *Akbar*, *Hegari* and *NARC-5* varieties of maize, sorghum and millet, respectively, were grown under uniform recommended agronomic practices in experimental plots (Each plot size was 1.8 x 6 m) for this study. Seed of maize, sorghum and millet was sown @ 100, 75 and 15 kg/ha, respectively (Ahmad *et al.,* 2003) using hand drill. The rows were 30 cm apart. The field was fertilized uniformly @ 60 kg each of N and P/ha in such a way that full dose of phosphorus (diammonium phosphate) and half of nitrogen (urea) was applied at the time of sowing (Ahmad *et al.,* 2003). The remaining half dose of nitrogen was applied after one month of sowing. During the experimental period, the field was irrigated thrice from dam water with an interval of 15 to 21 days. One hoeing was done before the first irrigation.

Preparation of laboratory silos: The fodders were manually harvested at three stages of maturity. Maize, sorghum and millet fodders were harvested at pre-heading (**CS_1**), heading (**CS_2**) and milk stage (**CS_3**). Laboratory scale silages were prepared from these fodders. The polyethylene bags (laboratory silos) were filled and then sealed to maintain anaerobic conditions. These silos were kept at room temperature (around 30^oC) for 60 days. After opening these silos, pH (Grewal *et al.,* 2003), lactic acid (Pennington & Sutherland 1956) and ammonia nitrogen (Anon., 1990) were determined immediately. The samples were also analyzed for **DM**, **CP** using method described by AOAC (Anon., 1990), nutrient digestible fibre (**NDF**), acid digestible fibre (**ADF**), acid digestible lignin (**ADL**) by the methods of Goering & Van Soest (1970) and water soluble carbohydrate (**WSC**) by the procedure of Johnson *et al.* (1966). Total digestible nutrient (**TDN**) and metabolizeable energy (**ME**) contents of each silage sample of fodder cut at three vegetative stages were calculated by the equations of Wardeh (1981) & Moe and Tyrrell (1976), respectively.

Statistical analysis: Data of chemical composition and digestibility of silages at three vegetative stages were statistically analyzed by using Completely Randomized Design. Duncan's Multiple Range tests were used to compare the treatment means (Steel & Torrie, 1980).

Results and Discussion

Effect of plant maturity on silage nutrient concentration: The respective DM, NDF, ADF and ADL contents of maize, sorghum and millet silages increased ($p<0.05$) with the advancement of fodder growth (Table 1). However, CP, TDN and ME contents of maize, sorghum and millet silages decreased ($p<0.05$) as the fodders advanced in age.

Table 1. Dry matter, crude protein, cell wall contents, total digestible nutrient and metabolizable energy (%DM) of experimental fodder silages at different stages of maturity.

Parameters	Cutting stages [1]	Fodder silages		
		Maize	Sorghum	Millet
	CS_1	18.09^c	15.78^c	14.32^c
Dry matter	CS_2	22.47^b	19.60^b	19.13^b
	CS_3	31.14^a	29.79^a	29.07^a
	S.E	**1.93**	**2.15**	**2.19**
	CS_1	13.30^a	08.90^a	8.84^a
Crude protein	CS_2	10.65^b	07.00^b	7.26^b
	CS_3	08.82^c	06.06^c	5.18^c
	S.E	**0.66**	**0.42**	**0.52**
	CS_1	66.60^c	68.40^c	68.70^c
Neutral detergent fibre	CS_2	68.50^b	69.01^b	69.70^b
	CS_3	71.40^a	71.70^a	72.40^a
	S.E	**0.74**	**1.60**	**0.59**
	CS_1	37.73^c	40.29^c	42.00^c
Acid detergent fibre	CS_2	39.07^b	41.09^b	44.47^b
	CS_3	39.70^a	43.50^a	45.80^a
	S.E	**0.29**	**0.49**	**0.56**
	CS_1	3.00^c	3.83^c	4.20^c
Acid detergent lignin	CS_2	3.45^b	4.46^b	6.00^b
	CS_3	5.35^a	5.71^a	6.92^a
	S.E	**0.36**	**0.28**	**0.40**
	CS_1	63.82^a	61.97^a	60.59^a
Total digestible nutrient	CS_2	60.84^b	58.54^b	57.80^b
	CS_3	58.12^c	56.93^c	55.75^c
	S.E	**0.82**	**0.76**	**0.70**
	CS_1	02.39^a	02.31^a	02.24^a
Metabolizable energy (Mcal/Kg)	CS_2	02.26^b	02.16^b	02.10^b
	CS_3	02.15^c	02.08^c	02.02^c
	S.E	**0.04**	**0.03**	**0.03**

Means in the same column bearing different superscripts were significantly ($p<0.05$) different

[1]CS_1, CS_2 and CS_3 stand for pre heading, heading and milk stages, respectively.

The results of this study were consistent with findings of other workers (St. Pierre *et al.,* 1987; Johnson *et al.,* 2002), who reported that CP content of fodder silages decreased with advancing maturity of fodder. Similarly, Phipps & Wilkinson (1985) reported that energy content of maize silage decreased as fodder advanced in age. Aerts *et al.* (1984/85) reported that DM contents increased from 18.7 to 36.5% and fibre contents increased from 15 to 30.5% in maize silages when maize fodder was harvested at early milk to late dough dent stage.

Johnson *et al*., (2002) reported that DM contents of corn silages increased from 26.24 to 35.25%, when harvested at hard dough to 2/3 milk line stages, however, CP contents decreased from 8.47 to 8.22% with increased maturity.

Cell wall contents of silage increased when it was prepared from fodder having 30 to 36% DM and thereafter cell wall contents decreased as grain maturity advanced (Sonon & Bolsen 1996; Bal *et al.,* 1997).

Silage characteristics: The respective WSC content, pH and ammonia nitrogen (NH_3-N) of silages of maize, sorghum and millet decreased ($p<0.05$) as the fodder advanced in age (Table 2). However, lactic acid contents in maize (4.63 to 9.12%), sorghum (3.00 to 6.80 %) and millet (2.70 to 6.16%) silages increased ($p<0.05$) with the advancement of maturity of these fodders.

Table 2. Silage characteristics of fodder at different stages of maturity.

Parameters	Cutting stages[1]	Fodder silages		
		Maize	Sorghum	Millet
	CS_1	5.09[a]	5.00[a]	4.70[a]
Water Soluble Carbohydrate (%)	CS_2	4.59[b]	4.50[b]	3.47[b]
	CS_3	4.02[c]	3.90[c]	3.00[c]
	S.E	**0.24**	**0.16**	**0.26**
	CS_1	4.20[a]	4.30[a]	4.45[a]
pH	CS_2	4.10[a]	4.23[ab]	4.30[b]
	CS_3	3.80[b]	4.10[b]	4.20[b]
	S.E	**0.07**	**0.04**	**0.04**
	CS_1	4.63[c]	3.00[a]	2.70[a]
Lactic acid (%)	CS_2	7.01[b]	5.83[b]	4.50[b]
	CS_3	9.12[a]	6.80[c]	6.16[c]
	S.E	**0.65**	**1.57**	**0.51**
	CS_1	8.00[a]	9.00[a]	10.50[a]
NH_3-N (% of total N)	CS_2	4.80[b]	5.60[b]	08.00[b]
	CS_3	3.50[c]	4.25[c]	06.00[c]
	S.E	**0.67**	**0.71**	**0.65**

The pH of maize fodder ranges from 6.53 to 6.9; sorghum fodder from 6.5 to 6.8 and millet fodder from 6.4 to 6.8. Means in the same column bearing different superscripts were significantly ($p<0.05$) different [1] CS_1, CS_2 and CS_3 stand for pre heading, heading and milk stages, respectively

The results of the present study supported the findings of Bergen *et al.* (1991), who reported that WSC was greater in silages made from barley, wheat and oats fodders harvested at milk stages. McDonald. (1981) reported that plant cells were broken down and the plant juices (soluble carbohydrates) were released by plasmolysis, which was a pre-requisite for the development of the lactic acid bacteria during the early stages of ensilage.

Sarwatt *et al*., (1989) reported that pH values of maize silages decreased with advancing growth of fodder. The pH less than 4.2 was indicative of well-preserved silage (McCullough, 1978). In the present study, pH of maize (from pre heading to milk stage), sorghum and millet (at milk stages) silages were within the range of 3.80 to 4.2, indicating well-preserved silages. The pH of silage made from fodder of an early age did not decrease rapidly and this might be attributed to low available WSC content resulting in more ammonia produced from the breakdown of proteins.

The results of lactic acid contents in the present study supported by the findings of Johnson & McClure (1968), who ensiled maize fodder at 8 different stages of maturity. They found that lactic acid content was highest in silage at the lowest pH. Similarly, Bal *et al*., (1997) and Harrison *et al*., (1998) reported that lactic acid concentration was the greatest in silage made from maize fodder harvested at milk stage.

The results of NH_3-N contents of the present study were similar to those of Garcia *et al*., (1989) who reported that more NH_3-N was present in low DM silages than in high DM silages. They explained that the increase in the concentration of NH_3-N was inversely proportional to the DM content of the fodder ensiled. The amount of NH_3-N present in silages is a reliable indicator of the extent of proteolytic clostridial activity. The total nitrogen in the form of ammonia was on indication of extensive degradation of amino acid released through proteolysis (McDonald, 1981).

Ammonia-N in silage is generally expressed as a percentage of total nitrogen which should not exceed from 8 to10 % of total nitrogen in good silage (Schukking, 1994). In the present study, maximum NH_3-N content of millet silage cut at an early stage was 10.5% of total N. This indicated a low clostridial activity in three silages at all growth stages.

Conclusions

- The DM, NDF, ADF and ADL contents of maize, sorghum and millet silages increased with the advancement of fodder growth. However, CP, TDN and ME contents of three silages decreased as the fodders advanced in age.
- The WSC content, pH and NH_3-N of maize, sorghum and millet silages decreased as the fodder advanced in age. However, lactic acid contents in three silages increased with the advancement of maturity of these fodders.

References

Aerts, J.V., J.L. DeBoever, B.G. Cottyn, D.L. DeBrabander and F. X. Buysse. 1984/85. Comparative digestibility of feed stuffs by sheep and cows. *Anim. Feed Sci. and Technol*., 12: 47-55.

Ahmad, M., A.H. Shah and M.A. Ali. 2003. Fodders (urdu version). Fodder Research Institute, Sargodha, Pakistan. Published by Ayub Agriculture Research Institute, Faisalabad, Pakistan, p. 5-25.

Anonymous. 1990. AOAC (Association of Official Analytical Chemists). *Official Methods of Analysis*. 15th Ed. Washington, DC, U.S.A.

Bal, M.A., J.G. Coors and R.D. Shaver. 1997. Impact of the maturity of corn for use as silage in the diets of dairy cows on intake, digestion and milk production. *J. Dairy Sci.*, 80: 2497-2503. http://jds.fass.org/content/vol80/issue10.

Bergen, W.G., T.M. Byrem and A.L. Grant. 1991. Ensiling characteristics of whole-crop small grains harvested at milk and dough stages. *J. Anim. Sci*., 69: 1766-1774. jas.fass.org/cgi/content/abstract/69/4/1766.

Carr, S.B., R.C. Hammes, A.J. Moe and M.L. McGilliard. 1984. Corn silage preservation with anhydrous ammonia, live culture microbial or organic acid based additives. *J. Dairy Sci.*, 67(7): 1474-1481. jds.fass.org/cgi/reprint/67/7/1474.pdf.

Church, D.C. 1991. *Livestock feeds and feeding. Feed Stuffs for Animals*. Part-II, 3rd edition, p. 91-92.

DeBoever, J.L., D.L. DeBrabander, A. M. DeSmet, J.M. Vanacker and C.V. Boucoue. 1993. Evaluation of Physical structure.2. Maize silage. *J. Dairy Sci.*, 76:1624-1634.

Fariani, A., L. Warly, T. A. Matsui, T. Fujihara and T. Harumoto. 1994. Rumen degradability of Italian Ryegrass (*Lolium multiflorum*,*L*) harvested at three different growth stages in sheep. *Asian-Aust. J. Anim. Sci*., 7 (1): 41-48.

Garcia, A.D., W.G. Olson, D.E. Otterby, J.G. Linn and W. P. Hansen. 1989. Effect of temperature, moisture and aeration on fermentation of alfalfa silage. *J. Dairy Sci.*, 72:. 93-103. jds.fass.org/cgi/content/abstract/72/1/93.

Goering, H.K. and P.J. VanSoest. 1970. *Forage fibre analysis*. United State Department of Agriculture, Agriculture Handbook, n. 379.

Grewal, R. S., S. Saijpaul and S. Kaushal. 2003. Effect of cotton stems addition on the chemical compsotion and *In-Sacco* dry matter digestibility of pearl millet silage. *Asian-Australasian J. Anim. Sci*., 16(12): 1722-1724. scialert.net/pdfs/ijar/2007/900-909.pdf.

Harrison, J.H., L. Johson, R. Riley, S. Xu, K. Loney, C.W. Hunt and D. Sapienza. 1998. Effect of harvest maturity of whole plant corn silage on milk production and component yield and passage of corn grain and starch into feces. *J. Dairy Sci.*, 79(1):149.

Johnson, R.R., T.L. Balwani, L.J. Johnson and K.E. McClure. 1966. Corn plant maturity, 2. Effect on *in vitro* cellulose digesti bility and soluble carbohydrate content. *J. Anim. Sci*., 25: 617: jas.fass.org/cgi/reprint/28/1/90.pdf.

Johnson, L.M., J.H. Harrison, D. Davidson, W.C. Mahanna, K. Shinners and D. Linder. 2002 Corn silage management: Effects of maturity, inoculation and mechanical processing on pack density and aerobic stability. *J. Dairy Sci.*, 85(2): 434-444. jds.fass.org/cgi/content/full/86/11/3675.

Johnson, R.R. and K.E. McClure. 1968. Corn plant maturity. IV. Effects on digestibility of corn silage in sheep. *J. Anim. Sci.*, 27: 535-540. jas.fass.org/cgi/content/abstract/27/2/535.

McCullough, M.E. 1978. Silage-some general consideration. Pages 1-26 in fermentation of silage-A review. (Ed.): M.E. McCullough. National Feed ingredients Assoc., West Des Moines, IA.

McDonald, P. 1981. *The biochemistry of silage*. John Wiley and Sons, Ltd. Chichester, United Kingdom.

Moe, P.W. and H.F. Tyrrell. 1976. Estimating metabolizable and net energy of feeds. Pages 232-236. In: *Proceeding. First International Symposium on feed composition*, (Eds.): P.V. Fonnesbeck, L.E. Harris and L.C. Kearl. Animal Nutrient Requirements and computerization of diets. Utah Agr. Exp. Sta. Utah State Univ., Logan.

Orskov, E.R., F.D.D. Hovell and F. Mould. 1980. The use of the nylon bag technique for the evaluation of feed stuffs. *Trop. Anim. Prod*., 5: 195-213.

Ouda, J.O., G.K. Njehia, G.B. Ashiono and M.K. Mbui. 2001. The potential of sorghum as ruminant feed resource. *Tanzania Society for Anim. Prod. Proc*., 28.

Panditharatne, S., V.G. Allen, J.P. Fontenot, and G.N. Jayasuriya. 1986. Ensiling characteristics of tropical grasses as influenced by stage of growth, additives and chopping length. *J. Anim. Sci.*, 63:197-207.

Pennington, R.J. and T.M. Sutherland. 1956. Ketone body production from various substrates by sheep rumen epithelium, *Biochem. J*., 63: 353.

Phipps, R. and M. Wilkinson. 1985. *Maize silage. Composition and nutritive value of maize silage*. Chalcombe Publications, Great Britain, p. 5-48.

Rasool, S., G. Ahmad and M. Abdullah. 1996. Fodder conservation, crop residuer and by products in livestock production system. *Proceeding of national conference on the improvement production and utilization of fodder crops in Pakistan*. March 21-27, Pakistan Agriculture Research Coubcil / FAO, Islamabad, Pakistan, p. 176-186.

Sarwar, M., M.A. Khan and Z. Iqbal. 2002. Status paper feed resources for livestock in Pakistan. Pakistan. *Int. J. Agric. Biol*., 4(1):186-192.

Sarwar, M., M.A. Khan and M. Nisa. 2004. Effect of urea treated wheat straw ensiled with organic acids of fermentable carbohydrates on ruminal parameters, digestion kinetics, digestibility and nitrogen metabolism in *Nili-Ravi* buffalo bulls fed restricted diets. *Asian-Australasian J. Anim. Sci.*, 1: 87.

Sarwatt, S. V., M. A. Mussa and J. A. Kategile. 1989. The nutritive value of ensiled forages cut at three stages of growth. *Anim. Feed Sci. Technol*. 22: 237-245.

Schukking, Ir. S. 1994. *Fodder conservation*. 1st training course for livestock production Officers, Pakistan. Research Station for cattle, sheep and Horse husbandry, Runderweg 6, Lelystad, the Netherland, p. 1.

St Pierre, N.R., R. Bouchard, G. Laurent, G.L. St Roy and C. Vinet. 1987. Performance of lactating dairy cows fed silage from corn of varying maturities. *J. Dairy Sci*., 70:108-115.

Steel, R.G.D and J.H. Torrie. 1980. *Principles and procedures of statistics*. 2nd edition. McGraw Hill Book Co, New York.

Sonon, R.N. and K.K. Bolsen. 1996. Effects of cultivar and stage of maturity on agronomic characteristics, chemical composition and nutritive value of forage sorghum silages. *Adv. Agric. Res.*, 5(3):1-17.

Sullivan, J.T. 1973. Drying and storing Herbage as Hay. *International: Chemistry and Biochemistry of Herbage* (Eds.): G.W. Butler and R.W. Bailey. Academic Press. London and New Yord, P. 4.

Wardeh, M.F. 1981. *Models for estimating energy and protein utilization for feeds*. PhD. Dissertation Utah State Univ. Logans.

(Received for publication 27 March 2010)