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The Effects of Harvest Period, Chopping Length and Compaction Pressure on Forage Quality of Sorghum (*Sorghum bicolor* L.) Silage

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Abstract: The aim of the study was to determine the effect of harvest period, chopping length and compaction pressure on forage quality of sorghum silage. The cv. snow was used as plant material. Sorghum crop has been harvested both in the milk and dough periods and were chopped within 1 and 4 cm in size then stored in a silo in 60 liter plastic barrels in compaction pressure values of 1, 2 and 3 MPa. At the end of the fermentation process, chemical analysis of sorghum silage was done and silage fodder quality classes were determined. The prolonged harvest period and increased chopping length has increased dry matter and pH value of silage whereas decreased crude protein content. The increasing compaction pressure has increased dry matter and crude protein content of silages and decreased pH value. Silages obtained at the end of the study were to be found very good quality class according to the Flieg scoring system.
Key Words: Sorghum silage, harvest period, chopping length, pressure leve

INTRODUCTION

Sorghum [*Sorghum bicolar* (L.) Moench] is an important plant in the world with 42.5 million ha of cultivated area and almost reached 54.5 million tons of total production. It is growing in general more tropical regions and also are known as alternative to corn (*Zea mays* L.) in hot and dry areas where corn can not be adapted. Sorghum is replaced with wheat [*Triticum aestivum* (L.)] in Africa and some far Asian countries and it has been widely using as animal feed in United States, South America and European countries (Tiryaki, 2005).

With regard to sorghum, Tiryaki (2005) reported genetic origin, used areas, cultivation techniques and biotechnological developments of it and another researchers, Demirel *et al.*, (2006) determined fermentation quality and digestibility of sorghum and sunflower alone or in combination of silage in a silo. Savoie *et al.,* (2002), reported the effects of moisture in silo for silage production, the chopping length and compaction pressure on the quality of silage fodder. Johnson *et al.,* (2005) showed the effects of chopping length and compaction density on pH, lactic acid and feed quality of silage obtained from alfalfa and rye crops. Shinners *et al.,* (2007) searched the effects of harvest period, storage media and chopping length on quality of feed of silage. Filya *et al.*, (2001) and Guney (2003) investigated the effects of harvest period and the contribution of LAB inoculants on sorghum silage production and fermentation characteristics. Turemis *et al.*, (1997) investigated the effects of molasses salt, urea and chopped wheat as silage additives on sorghum silage feed.

The aim of this study was to determine the effects of harvest periods, chopping size and compaction pressures on feed quality of sorghum silage

MATERIALS and METHODS

The sorghum cv. snow was used as material. Sorghum plants were harvested in both milk and dough maturity periods separately. For harvest, a single silage machine, has 12 chopper knives, attached to a tractor has been used. A chopping length of 1 cm on the average was obtained in the harvesting carried out with 12 knives. When nine of chopping knives were removed an average chopping length of 4 cm was obtained by using the rest of 3 knives. Chemical composition of fresh material before ensiling was determined. Sorghum material for silage

production placed into 60 litter plastic barrels which have a closing mechanism with sealed top and clamps. Sorghum in plastics barrels was compressed vertically using a hydraulic press with the pressures of 1, 2 and 3 MPa. The method of complete filling predetermined by Yalcin and Cakmak (2005) was applied in processes of filling and compressing of plastics barrels. Harvest period x chopping length x compaction pressure (2 x 2 x 3) was considered main factors and a total of 36 barrels with three replications were filled. The sealed plastics barrels were stored at room temperature for sixty days for fermantation.

60-day at the end of the fermentation process plastic barrels has been opened, and some chemical analysis for determining quality of forage sorghum silage and silage feed quality classes were determined pH values of silage samples was determined according to Polan *et al.*, (1998), and using a pH-meter (HANNA pH-211). Dry matter (DM) and crude protein (CP) analysis were carried out following the method of A.O.A.C (1990), while acid detergent fiber (ADF) and neutral detergent fiber (NDF) analysis were done according to Van Soest *et al.,* (1991). The contents of lactic (LA), acetic (AA), propionic (PA) and butyric acids (BA) were measured by HPLC (device model: Agillent 1200, column type Alltech OA-1000) according to Suzuki and Lund (1980). The quality class of silage samples was determined by using Flieg equation (FS) (Kilic, 1986; Nauman and Bassler, 1993; Denek *et al.,* 2004, Demirel *et al.,* 2006), as flows;

Flieg Score= [220+ (2*silage dry content (%)-15)] – 40*silage pH value (1)

The variance analysis and Duncan multiple comparison test was used to compare results (Yildiz and Bircan, 1994). SAS 9.0 software package was used for this purpose.

RESEARCH FINDINGS

Dry matter, pH and organic matter contents of fresh sorghum plants harvested both milk and dough periods are given in Table 1. The average of dry matter and pH of sorghum harvested in milk maturation period was 330 g/kg and 6.2, whereas these values were 372 g/kg and 6.3 in dough maturation period, respectively. Crude protein at first harvest period was 85 g/kg DM and 71 g/kg DM at the second harvest period. ADF and NDF values were found to be 360 and 580 g/kg DM at milk maturation period and 355 and 549 g/kg DM at dough period.

The average dry matter ratio and pH at milk period of sorghum silage were 354 g/kg and 4.01 , while these values at dough period of silage were 383 g/kg and 4.11 (Table 2). Crude protein value of silage obtained milk period harvest was 80 g/kg DM and it was 67 g/kg at dough period. ADF and NDF values of milk and dough period harvested silages were 348 and 569 g/kg DM and 341 and 538 g/kg, respectivelye level of DM. Volatile fatty acids LA, AA, PA and BA were determined as 39, 16, 8 and 2 g/kg for the first and 37, 18, 13 and 3 g/kg DM at second harvest period. The Flieg score of silage calculated from pH and dry matter were 115 in milk harvest period and 117 in dough period (Table 2).

The average dry matter of sorghum silage obtained from average 1 cm and 4 cm chopping length were 359 g/kg and 378 g/kg, respectively (Table 3).

pH value for 1 and 4 cm chopping length were 4.04 and 4.09, crude protein values were 76 and 71 g kg DM, ADF values 335 and 353 g/kg DM and NDF values 557 and 550 g/kg DM, respectively. Volatile fatty acids for 1 and 4 cm chopping length were LA: 39 and 37 g/kg DM, AA:17 and 18 g/kg DM, PA: 11 g /kg DM in both chopping length, and BA: 2 g/kg DM level, respectively. Flieg score were 115 and 117 for the 1 and 4 chopping length (Table 3).

Table 1. The chemical composition of the harvest period of fresh material

Harvest period	DM (g/kg)	pH	CP (g/kg DM)	ADF (g/kg DM)	NDF (g/kg DM)
Milk period	330[b]	6.2	85[a]	360	580[a]
Dough period	372[a]	6.3	71[b]	355	549[b]

* Different letters in same column indicate significant differences between milk and dough periods ($p < 0.05$).

Table 2. The effect of harvest period on chemical composition and silage fodder quality classes in sorghum silage

Harvest period	DM (g/kg)	pH	CP (g/kg DM)	ADF (g/kg DM)	NDF (g/kg DM)	LA (g/kg DM)	AA (g/kg DM)	PA (g/kg DM)	BA (g/kg DM)	FS*	SQC
Milk period	354^{b}	4.01^{b}	80^{a}	348^{a}	569^{a}	39^{a}	16^{b}	8^{b}	2^{b}	115^{b}	Very good
Dough period	383^{a}	4.11^{a}	67^{b}	341^{b}	538^{b}	37^{b}	18^{a}	13^{a}	3^{a}	117^{a}	Very good

a, b, c: different letters in the same column indicated significant difference between the average ($p < 0.05$).
*: Flieg score calculation was taken as % of dry matter content. For this transformation [DM (%)] = [DM (g / kg) / 10] equation is used.

Table 3. The effect of chopping length on chemical composition and silage fodder quality classes in sorghum silage

Mince size	DM (g/kg)	pH	CP (g/kg DM	ADF (g/kg DM	NDF (g/kg DM	LA (g/kg DM)	AA (g/kg DM	PA (g/kg DM)	BA (g/kg DM)	FS*	SQC
1 cm	359^{b}	4.04^{b}	76^{a}	353^{a}	557^{a}	39^{a}	17^{b}	11	2	115^{b}	Very good
4 cm	378^{a}	4.09^{a}	71^{b}	335^{b}	550^{b}	37^{b}	18^{a}	11	2	117^{a}	Very good

a, b, c: different letters in the same column indicated significant difference between the average ($p < 0.05$).
*: Flieg score calculation was taken as % of dry matter content. For this transformation [DM (%)] = [DM (g / kg) / 10] equation is used.

Table 4. The effect of compaction pressure on chemical composition and silage fodder quality classes in sorghum silage

Compaction pressure	DM (g/kg)	pH	CP (g/kg DM)	ADF (g/kg DM)	NDF (g/kg DM)	LA (g/kg DM)	AA (g/kg DM)	PA (g/kg DM)	BA (g/kg DM)	FS*	SQC
1 MPa	364^{b}	4.11^{a}	72^{b}	341	541^{b}	37^{b}	18^{a}	11^{a}	2	113^{c}	Very good
2 MPa	371^{a}	4.06^{b}	73^{b}	346	556^{a}	37^{b}	17^{ab}	10^{ab}	2	116^{b}	Very good
3 MPa	371^{a}	4.01^{c}	76^{a}	346	564^{a}	39^{a}	16^{b}	9^{b}	2	119^{a}	Very good

a, b, c: different letters in the same column indicated significant difference between the average ($p < 0.05$).
*: Flieg score calculation was taken as % of dry matter content. For this transformation [DM (%)] = [DM (g / kg) / 10] equation is used.

For effects of compaction pressure of silage quality, we determined that at 1 MPa pressure compressed in silos, sorghum silages has average dry matter level of 364 g/kg, pH 4.11, crude protein level of 72 g/kg DM, ADF value of 341 g/kg DM, and NDF level of 541 g/kg DM. LA, AA, PA and BA levels were 37, 18, 11 and 2 g/kg, respectively. The average Flieg score at 1 MPa compressor pressure of silages compressed in silo was 113. At 2 MPa pressure level, average dry matter was 371 g/kg, pH values 4.06, crude protein 73 g/kg DM, ADF value 346 g/kg DM, and NDF level 556 g/kg DM. LA, AA, PA and BA levels were 37, 17, 10 and 2 g/kg DM. Flieg score was 116 at 2 MPa pressure level. At 3 MPa in the silos are sorghum silage, the average dry matter level of 371 g/kg, pH 4.01, crude protein level 76 g/kg DM, ADF value 346 g/kg DM, and NDF level 564 g/kg DM. LA, AA, PA and BA levels were 39, 16, 9, and 2 g/kg DM. The Flieg score was 119 under MPa pressure (Table 4). The effects of harvest period, chopping length and compaction pressure on silage pH value is given in Figure 1.

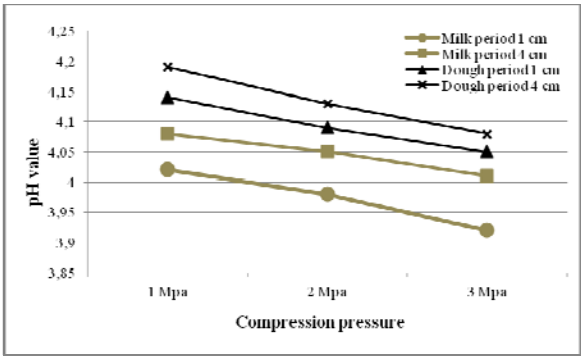

Figure 1. The effect of compaction pressure on pH values of sorghum silage

DISCUSSION and CONCLUSIONS

The progress of the harvest period, increased chopping length and compaction pressure increased the level of dry matter content of sorghum silage ($p<0.01$). Mc Donald (1981) reported that dry matter increase with the progress of the harvest period in silages. In the both harvest period of study, the rate of dry matter were found to be above 30% (33% and 37). Kilic (1986) and Filya (2002) suggested 30-40% dry matter for plants to obtain silage. Johnson *et al.*, (2005) and Yildiz (2008) refers, increased in chopping length increases the level of silage dry matter ($p<0.05$).

Progress of the harvest period and increase the chopping length increased pH value of silage, while increasing compaction pressure decreased pH value ($p<0.01$). The pH values of sorghum silage was the 4.01 and highest 4.11. A good-quality silage is should be pH value between 3.5 and 4.5 (Jeroch *et al.,* 1993; Muruz and Yoruk, 2000; Roth, 2001; Filya, 2001). Shinners *et al.*, (2007) stated that harvest period effect pH values of silage ($p<0.05$), Mc Donald (1981) reported that progress harvest period resulted decrease water-soluble carbohydrate content and the pH rises represent. Compaction with increasing pressures to reduce air space within silos and shortened duration of aerobic respiration and lactic acid bacteria fermentation process that starts early (Muruz and Yoruk, 2000; Filya, 2001). This situation is relevant for better fermentation with low pH values increased silage quality.

The crude protein value of sorghum silage is decreased with progressed harvest period and chopping length increase, the compaction pressure is increasing with increase ($p<0.01$). The progress of harvest period and increase of chopping length decreased ADF and NDF values of sorghum silages ($p<0.05$). Increasing compaction pressure were found non significant in ADF and NDF values ($p>0.05$). Mc Donald (1981) reported that progress of the harvest period increased cellulose and lignin within the plant and resulted decrease the degree of digestion of organic matter.

The lactic acid level of sorghum silage were decreased with harvest period progressively and chopping length increase. It was increased with compaction pressure increase ($p<0.01$). Acetic acid level were affected by harvest period ($p<0.01$), the chopping length and compaction pressure ($p<0.05$). Propionic acid levels increased progressively during the harvest period ($p<0.01$), the chopping length was not affected it ($p>0.05$), and decreased with increasing compaction pressure ($p<0.05$). Butyric acid levels increased during the harvest period progress ($p<0.01$), the chopping length and compaction pressure was not effect it ($p>0.05$). A good-quality silage should include LA level above 20 g/kg DM, the level of AA not excess 8 g kg DM and should include butyric acid. In general 1-7 g/kg DM of butyric acid values are observing in silages (McDonald, 1981; Kilic, 1986; Alcicek and Ozkan, 1996). Roth (2001) reported that usually lactic acid, acetic acid, propiyonic acid and butyric acid level of silages should has 40-60 g/kg DM, less than 20 g/kg DM, less than 10 g/kg DM and 1 g/kg DM, respectively. In our study the minimum and maximum level of lactic, acetic, propionic and butyric acid of sorghum silage were found between 37-39 g/kg DM, 16-18 g/kg DM, 8-13 g/kg DM and 2-3 g/kg DM, respectively. Based on these values, we can say that sorghum silage has passed a healthy process of fermentation.

The Flieg score calculated by using dry matter content and pH value has increased with progress of harvest period, increasing chopping length and compaction pressure ($p<0.01$). The increase of dry matter with progress of harvest period may have effect the increase of Flieg score. The silages has been found the best quality class when consider all three parameters.

REFERENCES

Alcicek, A., K. Ozkan, 1996. Distillation Method of Feed Bins and Milk Acid, Acetic Acid and Butyric Acid Determination. Aegean Univ. Journal of Agr. Fac. 33(2-3), 191-198.

AOAC 1990. Official Methods of Analysis of the Association of Analytical Chemists Official. 15 th Edn. Vol.1, Washington, DC,

Demirel, M., D. Bolat, S. Celik, Y. Bakici, A. Tekeli, 2006. Evaluation of Fermentation Qualities and Digestibility of Silages Made from Sorghum and Sunflower Alone and the Mixtures of Sorghum-Sunflower. Journal of Biological Sciences 6 (5): 926-930.

Denek, N., A. Can, S. Tufenk, 2004. Corn, Sorghum and Sunflower Silage Quality Achieved With the Participation of Various Additives and The Effect of in Vitro Dry Matter Digestion. Harran Univ. Journal of Agr. Fac. 8(2): 1-10.

Filya, I., 2001. Silage Fermentation. Ataturk Univ. Journal of Agr. Fac. 32 (1), 87-93.

Filya, I., A. Karabulut., H. Kalkan., E. Sucu., 2001. Sorghum Silage Inoculants Bacterial Fermentation, Aerobic Stability and Ruminal Degradability Effects on Properties. Ankara Univ. Faculty of Agriculture Journal of Agricultural Science, 7:112-119.

Filya, I., 2002. Silage Production. Breeding Forage Crops and Silage Production. Hasad Publishing, Kayseri, 59-86.

Guney, M., 2003. Harvest Period on Quality of Sorghum Silage, Lactic Acid Bacteria Inoculants and The Effects of Open Time. MS Thesis. Yuzuncu Yıl University, Graduate School of Science, Animal Science Department, Van.

Jeroch, H., G. Flachowsky, F. Weissbach, 1993. Futtermittelkunde. Gustav Fischer Verlag, Stuttgart.

Johnson, HE., RJ, Merry., DR, Davies., DB, Kell., MK, Theodorou., GW, Griffith., 2005. Vacuum Packing: a Model for Laboratory-Scale Silage Fermentations. Journal of Applied Microbiology 98 (1): 106-113.

Kilic, A., 1986. Feed silos (Teaching, Learning and Practice Recommendations). Bilgehan Press, 327 pp, Izmir.

Mc Donald., 1981. The Biochemistry of Silage. JW Publ. Manchester.

Muruz, H., MA, Yoruk., 2000. Microbiology and Biochemistry of Silage. Yuzuncu Yıl University Faculty of Veterinary Medicine Journal, 11 (1): 130-134.

Nauman, C., R. Bassler, 1993. Die Chemische Untersuchung von Futtermittein.

Polan, C.E., D. Stieve., J. Garrett., 1998. Protein Preservation and Ruminal Degradation of Ensiled Forage Treated with Heat, Formic Acid, Ammonia or Microbial Inoculants. Journal of Diary Science, 81, 765-776.

Roth, GW., 2001. Corn Silage Production and Management. College of Agricultural Sciences. Agricultural Research and Coop. Extension, Agronomy Facts 18

Savoie, P., A. Amyot., R. Theriault., 2002. Effect of Moisture Content, Chopping and Processing on Silage Effluent. Transactions of the ASAE, Vol. 45 (4), 907-914.

Shinners, KJ., BN, Binversie., RE. Muck., PJ, Weimer, 2007. Comparison of Wet and Dry Corn Stover Harvest and Storage. Biomass and Bioenergy 31:211-221.

Suzuki, M., CW, Lund., 1980. Improved Gas-Liquid Chromatography for Simultaneous Determination of Volatile Fatty Acids and Lactic Acid in Silage. J. Agric Food Chem. 28, 1040-1041.

Tiryaki, I.., 2005. Sorghum: Genetic Origin, Usage, Production Techniques and Developments in Biotechnology, KSU Journal of Science and Engineering 8(1).

Turemis, A., M. Kızılsimsek., S. Kizil., I. Inal., T. Saglamtimur, 1997. Some Additives, Summer Fodder Crops Grown in the Cukurova Conditions and Determine Their Effects on Silage Made From the Mixture of an Investigation. Proceedings of the First Silage Congress of Turkey. Hasad Publishing, s.166-175, Istanbul.

Van Soest, PJ., BJ, Robertson., BA, Lewis., 1991. Methods for Dietary Fiber, Neutral Detergent Fiber and Non-Starch Polysaccharides in Relation to Animal Nutrition. J. Dairy Science 74:3583-3597.

Yalcin, H., B. Cakmak., 2005. Compressibility Properties of Some Fodder. Aegean University Scientific Research Project Final Report, Project No: 01-ZRF-42, Izmir.

Yildiz, N., H, Bircan., 1994. Research and Test Methods, Ataturk University Publication No: 697, Erzurum.

Yildiz, C., 2008. Determination of the Proper Parameters For Packed Corn Small Bale Silage Making in Different Conditions. Ataturk University Graduate School of Science Dissertation, Department of Agricultural Machinery, Erzurum.