

Full Length Research Paper

Effects of chopping length and compaction values on the feed qualities of sunflower silage

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Accepted 5 July, 2010

This study was conducted to determine the feed qualities of sunflower silages produced with different chopping lengths and under different compaction values. Olivia species sunflower was used in the study. Sunflowers were harvested at the grain-dough maturity stage using silage machine. Dry matter rate on harvesting was 298.5 g/kg and plants were cut in the lengths ranging between 1 and 4 cm. Cut material was divided into three groups in three different plastic containers, which have the same volume of 60 L and these containers were applied to three different compaction values of 1, 2 and 3 MPa, respectively using a hydraulic press whose pressure values can be regulated. At the end of the fermentation period of 60 days, sunflower silages were analysed chemically. Mean dry matter content of total sunflower silages was 287.2 g/kg, mean pH value was 4.29, crude protein content was 95.5 g/kgDM, ADF content was 429.6 g/kgDM, and NDF content was 434.6 g/kgDM and Fleig score was 91.04. Larger chopping length increased the pH value of sunflower silage ($p < 0.01$) and ADF content ($p < 0.05$), while decreasing the Fleig score ($p < 0.01$). Under increased compaction values, pH values decreased ($p < 0.05$) and Fleig score increased ($p < 0.01$). It was consequently found in the study that sunflower silage with higher feed quality was obtained with the crops harvested at grain-dough maturity stage, cut into 1 cm length and compressed under 3 MPa.

Key words: Sunflower silage, chopping length, compaction, feed quality.

INTRODUCTION

Sunflower is an important oil plant. The oil content of the seed is between 40 and 50% (Eken, 2004). In 2006, 28 million tons of sunflowers were harvested from a land surface of approximately 22 million ha in the world (Anonymous, 2008). In Turkey, the area of sunflower has increased 37 folds; production and crop yield rates increased 44 and 39 folds, respectively, and consequently, the country ranked eighth in sunflower production in the world (Fidan and Ozçelik, 2003). Sunflower oil is among the most preferred edible plant oils for its quality. Therefore, majority of the harvested sunflower oil is used to produce cooking oil. In addition, oil production sunflower can also be used as bird feed, to produce bagasse from its seed crust, as fuel (its stem) and an alternative silage plant.

Murphy (1978) reported that sunflower can reach maturity quickly and is tolerant to cold and drought. Garcia (2006) stated that a dry matter rate of 300 g/kg is suitable for ensiling sunflower, and sunflower silage contains more crude protein, calcium and lipid than corn silage with the same dry matter content. Valdez et al. (1988) found that sunflower silage with a dry matter content of 22.8% has pH value of 4.4, crude protein rate of 10.6%, ADF of 30%, NDF of 43.5%. Stan (2001) determined that sunflower silage containing a dry matter of 30% had CP of 12.5% and ADF of 39%. Fassio et al. (2007) stated that pH value of sunflower silage with 220 g/kgDM rate was 5.3, while CP, ash, ADF and NDF content were 120, 130, 390 and 560 g/kgDM, respectively. Demirel et al. (2008) found the pH, ADF, and NDF content of sunflower silage with dry matter content of 212 g/kgDM to be 4.35, 375.6 and 409.7 g/kgDM, respectively.

Tan and Tümer (1996) in their study, investigated the quality of silage produced from the sunflowers harvested at different stages of maturity, they also stated that the

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most suitable harvesting stage is when efflorescence is completed. Toruk (2003), found that sunflower silage produced with harvesting at two stages of maturity dry matter contents of 207 and 264 g/kgDM at the efflorescence and grain milk maturity are completed, respectively. Denek et al. (2004) in their study, investigated the effects of various additives on the quality of sunflower silage, that additives of urea, urea plus molasses and urea plus ground wheat grain increase the pH values of silages. Demirel et al. (2008) found in their study, where they produced silage mixing with the residues of sunflower and corn discretely and at various rates, that it is possible to obtain high quality silage from sunflower alone. Gregoire (1999), stated that chopping length of sunflower in silage production should be between 2.5 and 4 cm while Garcia (2006) found that protein content of sunflower increases until head formation and begins to decrease after the formation of head, while sugar content is larger in stem than that in leaves.

The purpose of this experiment was to study the effect of chopping length and compaction pressure on the quality of sunflower silages.

MATERIALS AND METHODS

Experimental materials and procedures

In the study, Sunflower (cultivar Olivia species) was used as silage material. Whole plant was harvested including grains, heads and stems at grain dough maturity stage. In the harvesting process, one-lined silage machine pulled by tractor was used. This machine has 12 chopping knives. A chopping length of 1 cm on the average was obtained as a result of the harvesting carried out with 12 knives. When nine of the knives were removed, an average 4 cm chopping length was obtained. According to their weights, salt and ground barley were added to chopped sunflower of both chopping lengths in the rate of 20 and 40 kg/ton, respectively (Kilic, 1986). Chemical composition of fresh material at the beginning of the ensiling was determined by sampling the freshly chopped sunflower biomass. Sunflower silages were prepared in plastics barrels with volume of 60 L equipped with a sealing lid. Sunflower silage in the plastics barrels was compressed vertically by hydraulic press under the pressures of 1, 2 and 3 MPa. The method predetermined by Yalcin and Cakmak (2005), was applied in the process of filling and compressing the plastics barrels. Plastics barrels sealed to proof air were left for fermentation period of sixty days.

Analysis

At the end of the fermentation period, barrels were opened and chemical analyses were carried out to determine the feed quality and silage quality of the sunflower silage. pH values of silage samples were measured according to Polan et al. (1998) using a pH-meter (HANNA-pH 211). Dry matter content and crude protein analyses were carried out following the method reported in AOAC (1990), while ADF and NDF analyses were done according to Van Soest et al. (1991). In determining the quality of the silage samples, the following Fleig equation was used (Kilic, 1986; Nauman and Bassler, 1993):

$$\text{Fleig score} = [220 + (2 \times \text{silage dry matter content (\%)} - 15)] - 40 \times \text{silage pH value}$$

Statistical analysis

Statistical analysis included two-way analyses of variance and Duncan's multiple rang was used for the determination of the differences between the groups (Yildiz and Bircan, 1994), using SPSS 13.0 software package.

RESULTS AND DISCUSSION

Table 1 presents the results of the chemical analysis conducted for the determination of feed quality of sunflower silages produced by chopping sunflower which were harvested at grain dough stage at 1 and 4 cm and compressing them in 60 L barrels under pressures of 1, 2 and 3 MPa. Mean dry matter rate of all the sunflower silage samples obtained at the end of the fermentation process was 287.2 g/kg. Ergül (1988) reported that dry matter content should be between 250 - 350 g/kg for quality silage, which was in agreement with the findings in the present study.

Mean dry matter rate of silages obtained with the residue with 4 cm size was 290 g/kg while it was 284.4 g/kg in those with 1 cm size. The increased chopping length size also increased the dry matter rate of the samples ($p > 0.05$). On the other hand, increased pressure also increased the dry matter content of silage samples ($p > 0.05$). Mean dry matter content of samples exposed to 1 MPa pressure was 281.7 g/kg while this value was 288.4 and 291.7 g/kg under pressures of 2 and 3 MPa, respectively. Mean dry matter content of all the sunflower silage samples was 287.2 g/kg, which is higher than the values of 225, 264, 166, 220 and 212 g/kg found by Valdez et al. (1988), Toruk (2003), Denek et al. (2004), Fassio et al. (2007) and Demirel et al. (2008), respectively, and lower than 300 g/kg reported by Stan (2001) and Garcia (2006).

The values pH is important in silages in order to determine if the silage under vent is an adequate fermentation process and these values are important indicator in the determination of feed quality silage. pH values which are generally between 6 and 7 at the beginning of ensiling period, decreased to about 3.5 and 4.5 at the end of this period (Muruz and Yörük, 2000; Filya, 2000; Ashbell et al., 2001; Deniz et al., 2001; Roth, 2001; Savoie et al., 2002). For all the silage samples analysed in the present study, mean pH value was 4.29, which is in the range of ideal threshold values 3.5 - 4.5, as mentioned above. In this respect, it can be said from the present study that sunflower silages were well fermented and reached stability. Mean pH value of 4.29 which was found in the present study is lower than those reported by Valdez et al. (1988), Fassio et al. (2007) and Demirel et al. (2008), which are 4.4, 5.3 and 4.4,

Table 1. Chemical composition, Fleig score and silage quality class of sunflower silage.

Parameters	DM (g/kg)	pH	CP (g/kgDM)	ADF (g/kgDM)	NDF (g/kgDM)	FS*	SQC
Fresh mat.	298.5	6.32	112.0	440.5	441.3	-	-
Chopping length 1 cm							
1 MPa	280.0	4.23 c	95.6	431.1	427.9	91.80 b	Excellent
2 MPa	285.0	4.22 c	97.7	443.9	441.3	93.20 a	Excellent
3 MPa	288.3	4.20 c	99.2	461.1	447.5	94.66 a	Excellent
Chopping length 4 cm							
1 MPa	283.3	4.43 a	91.7	402.0	418.6	84.46 c	Excellent
2 MPa	291.7	4.32 b	93.5	416.9	428.9	90.54 b	Excellent
3 MPa	295.0	4.31 b	95.1	422.3	443.1	91.60 b	Excellent
Average	287.2	4.29	95.5	429.6	434.6	90.84	Excellent

DM: dry matter content, CP: crude protein, ADF: acid detergent fiber, NDF: neutral detergent fiber, FS: Fleig score, SQC: silage quality class. a, b, c: Differences between the means shown with different letters in the same column are significant ($P < 0.05$). *: Dry matter content of silage was taken as percent. (DM (%) = DM (g/kg)/10).

respectively while being higher than that reported by Denek et al. (2004), which is 4.27. pH values increased with the increasing chopping length ($p < 0.01$). These values were 4.22 and 4.35 in 1 and 4 cm chopping length, increased by 0.13 between two chopping treatments. This can be explained by the larger surface area of the smaller particles which enabled more intensive fermentation by lactic acid bac-teria. Increased pH values with the increased chopping sizes were also reported by Iptaş and Avcioglu (1997), Savoie et al. (2002), Shinnars et al. (2007) and Yildiz (2008), in their studies carried out on corn. Increased compressing pressure values decreased the pH values of silage samples ($p < 0.05$). It was found in the present study that pH values of 4.33, 4.27 and 4.26 were obtained under 1 MPa, 2 MPa and 3 MPa pressure values, respectively, which means that as the pressure increases pH values decrease ($p < 0.05$). Same finding that increased pressures can cause lower pH values which was reported by Savoie et al., (2002) and Yildiz (2008), in their study over corn.

Mean crude protein (95.5 g/kgDM) content of sunflower silage in the present study is lower than the values reported by Valdez et al. (1988), Stan (2001), Denek et al. (2004), and Fassio et al. (2007), which were 106, 125, 209 and 120 g/kgDM, respectively. Crude protein content decreased with increased chopping length ($p > 0.05$). In the sample with 1 cm chopping length, crude protein content was 97.5 g/kgDM, which reduced to 93.4 g/kgDM, in the sample with 4 cm chopping length. With the increasing pressure crude protein content also increased in sunflower silages in this study ($p > 0.05$). Crude protein contents were 93.7, 95.6 and 97.2 g/kgDM under the pressures of 1, 2 and 3 MPa pressures. Yildiz (2008) stated that with increased chopping sizes, crude protein rate of silage ecreased while increased pressures increased it.

Mean ADF content of sunflower silages in the study was 429.6 g/kgDM. This content of ADF decreased with the increased chopping length ($p < 0.05$) reducing from 445.4 g/kgDM in the first chopping length to 413.7 g/kgDM in the second. Increased pressure also increased the ADF content of silages ($p > 0.05$). ADF contents of 416.6, 430.4 and 441.7 g/kgDM were obtained under 1, 2 and 3 MPa pressures, which shows a consistent increase in ADF. Mean ADF content of 429.6 g/kgDM is higher than all the values reported by Valdez et al. (1988), Stan (2001), Denek et al. (2004), Fassio et al. (2007) and Demirel et al. (2008), which were 300, 390, 312, 390 and 376 g/kgDM, respectively in sunflower silages.

For the sunflower silages produced in the present study, mean NDF contents (434.6 g/kgDM) which is the same with the value reported by Valdez et al. (1988) (435 g/kgDM) for sunflower was lower than that in Fassio et al. (2007) (560 g/kgDM) and higher than those in Denek et al. (2004) and Demirel et al. (2008) (277 and 410 g/kgDM, respectively). Increase in the chopping length decreased NDF contents in sunflower silages ($p > 0.05$). Mean NDF contents were 438.9 and 430.2 g/kgDM for 1 and 4 cm chopping length, which shows a decrease. NDF values increased with increased pressure values ($p > 0.05$). NDF contents of 423.6, 435.1 and 445.3 g/kgDM were found under 1, 2 and 3 MPa pressures, which show an increase.

The Average mean Fleig scores of sunflower silages in the study, which were calculated based on the pH and dry matter content of silages and using Fleig equation, was found to be 91.04. This value coincides with the "excellent" quality according to Fleig scoring system. Silage quality class of silages produced under different conditions was found to be excellent. Denek et al. (2004) found in sunflower silage without additives, the average of mean Fleig scores to be 67.56 and quality class of

silage was “good”, while Demirel et al. (2006) found in the same silage type, the Fleig score to be 72.17 and the quality class was good, all of which were less than the values found in the present study.

Since the increased chopping length increased the pH values, Fleig scores decreased ($p < 0.01$). While Fleig score was 93.22 in the first chopping length, it was 88.87 in the second length. In addition, as a result of increased pressure, pH decreased and dry matter contents increased in the produced silages in the present study, thereby resulting an increase in Fleig score ($p < 0.01$). Fleig scores were 88.13, 91.87 and 93.13 under 1, 2 and 3 MPa pressures, which shows a clear increase.

CONCLUSION

All the sunflower silages produced by harvesting at grain dough maturity stage at a dry matter content of 290 g/kg, chopping in the lengths of 1 and 4 cm and under 1, 2 and 3 MPa pressures were found to be of excellent quality. Silages produced in the scope of study with mean pH of 4.29, mean dry matter content of 287.2 g/kg and crude protein content of 95.5 g/kg.DM were found to have the features of ideal silage. However, when considering the dry matter content, pH values, crude protein content, ADF and NDF content and Fleig scores, it was concluded that sunflower residues should be cut into 1 cm size and compressed under 3 MPa pressure.

ACKNOWLEDGMENTS

The authors are grateful for field, machine and silage material support from the Center of Agricultural Research of Atatürk University, Erzurum, Turkey. The first author thank Prof. Zwika Weinberg from the Agricultural Research Organization, The Volcaney Center, Israel for reviewing the manuscript.

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