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EFFECTS ON SILAGE QUALITY AND AEROBIC STABILITY OF DIFFERENT COMPACTION LEVELS IN SUNFLOWER SILAGE

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Abstract

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In this study, the effects of different compaction levels on the silage quality and aerobic stability of sunflower silage harvested at the beginning (BFS) and end of the flowering (EFS) stages were investigated. Four compaction applications (no compaction (NC), compaction with 150 kPa (C1), 248 kPa (C2) and 498 kPa (C3)) were done in the study. Each treatment was ensiled for 50 days in PVC type's silos with three replications. Temperature variations were recorded with 5 days interval after opening the silos to detect the aerobic stability of the treatments. It was observed that compaction levels had significant effect on some quality criteria of the BFS and EFS stages. Statistically significant differences were found among the values of pH, DM, NH_3-N, NH_3-N/TN, WSC, NDF and ADF in BFS stage against all parameters expect NDF and ADF in EFS stage. Silage characteristics were affected positive increasing compaction levels. Different compaction levels after the opening did not considerable effects on the aerobic stability.

Key words: sunflower silage, compaction level, silage quality, aerobic stability
Abbreviations: BFS-beginning of the flowering stage; EFS-end of the flowering stage; NC-No compaction treatment; C1-compaction with 150 kPa; C2-compaction with 248 kPa; C3-compaction with 498 kPa; CP-crude protein; DM-dry matter; EE-ether extract; NH_3-N-concentration of ammonia-nitrogen; NH_3-N/TN-total nitrogen; WSC-water-soluble carbohydrates; NDF-neutral detergent fiber; ADF-detergent fiber; ADL-acid detergent lignin; AA-acetic acid; LA-lactic acid; BA-butric acid

Introduction

Many factors affect the aerobic stability of silages. Oxygen is detrimental to silage quality because it enables aerobic spoilage microorganisms such as yeasts and moulds to grow (Woolford, 1990). Undesirable temperature increases can in many cases be attributed to insufficient compaction of the forage (Wagner, 2005). Silage may be exposed to air during storage and unloading for feeding, and so it is susceptible to spoilage, especially in warm climates (Ashbell et al., 2002). During silo unloading, silage is normally fully

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exposed to air, which could result in an increase in temperature and aerobic deterioration. The stability of silage in the presence of oxygen is a very important factor determining its subsequent nutritional quality and feeding value. Johnson et al. (1999) reported that there was no consistent trend of the effects of maturity on aerobic stability of maize silage. Higginbotham et al. (1998) and Filya (2003) found that maize silage harvested at early dent maturity stage was not stable aerobically when exposed to air.

Sunflower silage has low dry matter and high cell wall contents, which negatively affects silage quality but has high concentrations of crude protein and ether extract (Gregoire, 1999). Demirel et al. (2006) determined that sunflower silage had greater dry matter (DM), crude protein (CP) and ether extract (EE) but lower ADF and NDF digestibility compared with sorghum silage. As percentage of sunflower increased DM, CP and EE digestibility increased but ADF and NDF digestibility decreased in the mixtures. They found that better quality silages could be obtained by mixing sorghum and sunflower at 50% ratio.

The extent of aerobic losses from silage mainly depends on the management factors such as filling technique, density of material, sealing and unloading technique (Petterson, 1988).

To obtain silage of good quality and of high nutritive value, the material should be cut at the right point of maturity. Tan and Tumer (1996) ensiled sunflower at several stages of maturity and concluded that the final flowering stage was the best for silage making. The best harvest time for ensiling varied according to genotype (Goncalves et al., 1999).

The objective of the present study was to evaluate the effect of different stages of maturity on the nutritive value and aerobic stability of sunflower silage made at different compaction levels.

Materials and Methods

The sunflower (*Helianthus annuus* L.) seed used was Meric F1 which has medium maturation time and resistant to drought is used in the study. The chopped materials were bought to the laboratory at University where mini-silos filling and compaction were carried out under controlled conditions. Mini-silos made of a PVC pipe which having 100 mm inside diameter and 660 mm height, a volume of 5.2 L. The chopped material was filled with compaction mechanism. The experiment was organized in 2 (stages of maturity) x 4 (compaction treatments; NC, C1, C2 and C3) factorial arrangement of treatment. Each treatment combination was replicated four times. The geometric mean particle length of sunflower was 10.5 mm (Brooking, 2002).

The chopped material was filled with compaction. Trial set for compaction is shown in Figure 1.

The set has four units mainly. These are battery (1), numeric indicator (2) for converting signals (come from load cell) to numeric value, computer (3) for recording numeric values (coming from the numeric indicator) and load cell (4) for converting force to sig-

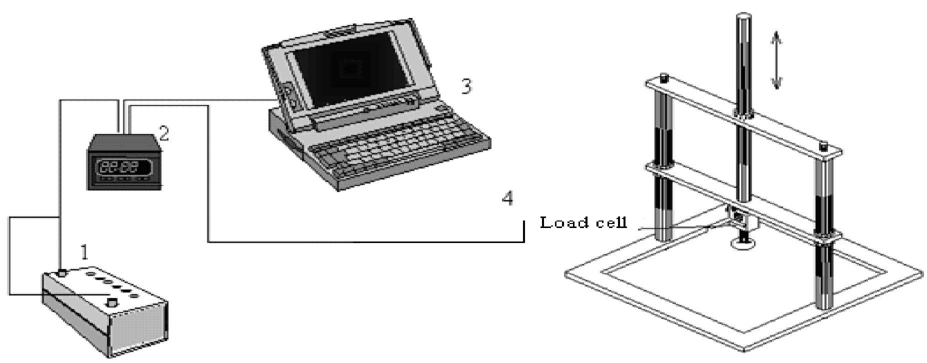

Fig. 1. Trial set for compaction and load measure: 1. Battery (dry); 2. Numeric indicator; 3. Computer; 4. Load cell

nal. ESIT, TCS 500 model load cell was employed by means of shear box method. A laptop computer and ProComm software were used to evaluate the numerical values.

After 50 days of ensiling, all the mini-silos were opened for analysis. The silages were subjected to an aerobic stability test lasting 5 days, in which silage temperatures were measured (Sanderson, 1993; Filya, 2004). A type T thermocouple was placed approximately 10 cm into the silage, and average silage temperatures were recorded hourly until heating occurred. Aerobic stability was defined as the time after opening for silage temperature to reach 2єC above ambient (Muck, 2002).

Dry matter (DM) was determined by oven drying at 103°C during 24 h (ASAE Standartds, 1994). Ash and Ether extract (EE) was measured by incineration during 4 h at 550°C (Bulgurlu and Ergul, 1978). The pH and fat values of both fresh material and silage materials were obtained using the methods reported by Chen et al. (1994). Total nitrogen (T) concentration was measured by a Kjeldahl procedure and CP concentration was calculated as Nx6.25 (Vadez, 1985; Stan, 2001). Acetic acid (AA), lactic acid (LA) and butric acid (BA) (%) were calculated according to Lepper method (Akyildiz, 1984). Neutral detergent fiber (NDF), detergent fiber (ADF) concentrations and acid detergent lignin (ADL) concentration was estimated according to Van Soest analysis method (Close and Menke, 1986). Concentration of ammoniac (NH_3), ammoniac-nitrogen (NH_3-N) and total nitrogen were determined for evaluating of silage quality (Brookэng, 2002). Water-soluble carbohydrates (WSC) were determined according to ADAS (1980).

Analysis of variance was made to determine significant differences between factors by using MSTAT computer program.

Results and Discussion

Effects of maturity stages (BFS and EFS) and compaction levels on fermentation characteristics of sunflower silage were significant (**$p<0.05$) and these are presented in Table 1.

Peterson (1988) stated that good quality silage pH should be under 4.3. pH values were favorable at the BFS and highest at the EFS. The DM content was increased in the silages with maturity and increasing compaction levels. Silage quality is highly related to DM content of silage material ensiled (Tan and Тьmer, 1996; Gregorie, 1999). While concentration of ammonia-nitrogen (NH_3-N), NH_3-N/TN, pH and EE contents were decreased with increasing compaction levels, DM content was increased. The fermentation characteristics of the silage were similar to trends found by Roy (2001).

NH_3-N contents were lowest at C3 and highest at NC (**$p<0.05$). CP concentration of silage was simi-

Table 1
Technical details of the load cell

Load capasity (=E_{max})	(N)	500
Stimulate voltage	(V)	10
Complete load output	(mV/V)	2±0.1%
Total error	(%E_{max})	0.03
Working temperature	(°C)	-20 and 80
Adjusting temperature	(°C)	-10 and 40
Safe excessive load	(%E_{max})	100
Max. resistance load	(%E_{max})	300
Max. load	(%E_{max})	100
Material	-	Steel (DIN 1. 4542)
Protect	-	IP68 (DIN 40050)

lar between applications. A lower pH in high moisture silage was expected because of higher concentrations of WSC and more extensive fermentation (McDonald et al., 1991). NH_3-N should be under 80 g kg^{-1} TN according to Peterson (1988). Values of BFS were low and values of EFS were high in our study. CP level at BFS was higher than EFS stage. Similar results were found by Stan (2001), Filya (2002) and Putnam et al. (1990).

The NDF, ADF and Crude fiber (CF) were increased in the silages with maturity. ADL content was decreased. NRC (1989) stated that NDF, ADF, ADL and CF should be 42, 39, 12 and 27%. In our study, NDF and ADF values were good at BFS stages but ADL was high. The ensiling and nutritional quality depends upon the stage of maturity at the time of harvest (Bal et al., 1997; Johnson et al., 1999) and also here. Average NDF, ADF and CF contents of silages were lowest at the BFS stage, and highest at the EFS stage of maturity. ADL content of the silages was lowest at the EFS stage, and highest at the BFS stage. The NDF, ADF and CF content of the sunflower silages increased with maturity but did not effect from compaction treatments. NDF content of silages increased from 39.28 to 47.86 g/kg and ADF increased from 36.64 to 41.82 g/kg with maturity (**p<0.05) (Table 2).

Alcicek and Ozkan (1997) were stated that the value of LA should be over 2.0% and for the value of AA should be below 0.8% in quality silage. The values of this study about LA were not sufficient, except C3 treatment at the BFS stage. Values of AA at all stages were found below 0.8%, except NC treatment at the EFS stage (*p<0.01). The lactic acid concentration was higher for BFS stage, than for EFS stages. A similar trend was shown by Filya (2004). The lowest levels of AA, and the highest values of LA, were in the silages of the BFS stage, compared to EFS stages (*P<0.01). WSC content was the highest at NC (McDonald et al., 1991).WSC values were changed with increasing compaction levels (Table 3). Figures 2 and 3 illustrated the effect of temperature differences for silages at BFS and EFS stage.

While temperature values had the highest 3th and 4th day at the BFS stage, the highest value at the EFS stage was determined 5th day.

At is point of temperature differences; it is possible to say that compaction treatments did not have any significant effect on aerobic stability of sunflower silage. But, aerobic stability of the sunflower silage was affected positive with moisture content.

Johnson et al. (1999) reported that there was no

Table 2
Chemical properties of the maturity stage and the compaction levels of sunflower silages, and levels of significance of factors

	Aplication	pH	DM (%)	NH_3-N	NH_3-N/TN	CP	EE
BFS	Fresh	4.74	21.51	-	-	11	1.85
	NC	3.79±0.01a	18.79±0.21a	1.04±0.00a	62±0.002c	10.37±0.25a	1.82±0.08b
	C1	3.77±0.01ab	19.64±0.12ab	0.73±0.09d	53.22±1.61b	10.02±0.40b	1.63±0.13c
	C2	3.65±0.01c	20.34±0.03bc	0.78±0.22d	61.09±1.24bc	10.00±0.23d	1.45±0.02e
	C3	3.65±0.03c	20.87±0.14c	0.73±0.08d	44.02±4.08a	10.60±0.27c	1.61±0.08d
EFS	Fresh	6.01	27.5	-	-	10	7.59
	NC	5.44±0.07c	26.04±0.16a	2.67±0.01b*	185±0.02b*	9.00±0.52b	6.82±0.23a
	C1	5.38±0.01c	26.57±0.05ab	2.88±0.01c*	225±0.10c*	8.40±0.09a	8.51±0.51b
	C2	5.18±0.07ab	27.40±0.07bc	2.20±0.01a*	163±0.03a*	8.44±0.06ab	8.79±0.09b
	C3	5.34±0.04bc	28.49±0.09c	2.19±0.02a*	161±0.01a*	8.49±0.12ab	6.62±0.35a

Mean values on the same column with the same superscript do not differ significantly at p≤0.05
* Mean values on the same column with the same superscript do not differ significantly at p≤0.01

Table 3
Effect of compaction treatments and maturity stages on the structural composition and silage quality parameters of the sunflower silage

	Aplication	NC	C1	C2	C3
BFS	NDF	39.28±1.05a	43.53±1.14c	39.52±0.35a	39.87±1.01 ab
	ADF	36.64±0.50 ab	39.37±1.21 b	36.20±0.37 a	36.92±1.08 ab
	ADL	15.39±1.00 ns	16.70±0.98 ns	17.77±1.44 ns	17.02±0.62 ns
	CF	22.78±0.17 ns	23.14±1.19 ns	22.42±0.40 ns	22.37±0.46 ns
	WSC	8.48±0.03d*	6.25±0.01b*	5.38±0.02a*	6.26±0.01c*
	LA	1.65±0.00b	1.36±0.01a	1.90±0.10c	2.05±0.05c
	AA	0.53±0.03b	0.30±0.05a	0.39±0.00ab	0.44±0.04ab
	BA	NF	NF	NF	NF
EFS	NDF	47.86±0.60 b	47.04±0.46ab	46.03±0.06ab	45.81±0.66ab
	ADF	41.82±1.16 ns	43.95±0.34 ns	42.73±0.00 ns	40.75±0.65 ns
	ADL	15.44±0.00b*	17.17±0.27d*	16.44±0.00c*	14.62±0.33a*
	CF	29.56±0.60a	32.05±0.44b	31.54±0.14b	31.67±0.75b
	WSC	11.15±0.03d*	7.49±0.02c*	3.83±0.01b*	3.53±0.01a*
	LA	0.88±0.01ab	0.75±0.05a	1.00±0.00b	1.50±0.10c
	AA	0.90±0.03c*	0.65±0.05b*	0.41±0.02a*	0.36±0.03a*
	BA	NF	NF	NF	NF

Mean values on the same row with the same superscript do not differ significantly at p≤0.05
* Mean values on the same row with the same superscript do not differ significantly at p≤0.01
NF:not found, ns:no significant.

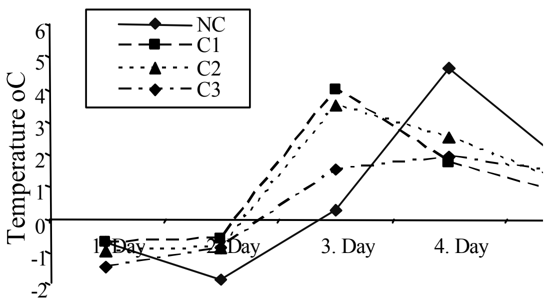

Fig. 2. Sunflower silage at the BFS temperature differences from ambient 5 day of air exposure

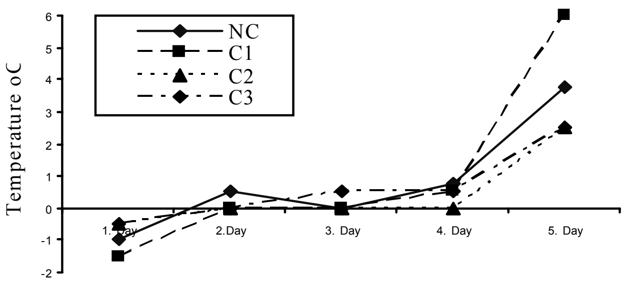

Fig. 3. Sunflower silage at the EFS temperature differences from ambient 5 day of air exposure

consistent trend of the effects of maturity on aerobic stability of maize silage. The silages of the EFS stage had higher pH than the EFS silages. Therefore, silages of the EFS stage spoiled upon aerobic exposure faster than the other silages.

Conclusion

- Fermentation characteristics of the sunflower silage were affected positive with increasing compaction levels. pH, KM, NH_3-N/TN, WSC, NDF and

ADF values at the EFS stage were significantly found.

- Compaction treatments did not have any significant effect on aerobic stability of sunflower silage.
- Aerobic stability of the sunflower silage was affected positive with moisture content. The silages of EFS stage exhibited good aerobic stability than the silage of the BFS stage.
- BFS had better ensiling properties than EFS's.

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