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Determination of Fermentation and Digestibility Characteristics of Corn, Sunflower and Combination of Corn and Sunflower Silages

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Abstract: This study was conducted to determine *in vivo* digestibilities and fermentation property of various silages made of green herbage of Sunflower (SF), Corn (C) and corn-sunflower mixtures at different rates [75% corn+25% sunflower (75C25SF), 50% corn+50% sunflower (50C50SF), 25% corn+75 sunflower (25C75SF)] ensiled in 120 l plastic barrels for 90 days. PH values of C and mixture silages were lower than that of SF silage ($p<0.05$). Concentrations of lactic, acetic, propionic and butyric acids were higher in SF silage than C silage ($p<0.05$). Lactic and propionic acid concentrations increased in mixture silages as the sunflower ratio increased, whereas decreases in butyric acid concentration were observed as corn ratio incresed in the mixture ($p<0.05$). While digestibility of DM, OM, ADF and NDF were high in C silage, digestibility of CP and EE were high in SF silage. The digestibility of DM, OM, ADF and NDF in mixture silages increased with the increases in corn ratio in mixture and digestibility of CP and EE of increased as sunflower ratio increased in mixture. It can be concluded that high quality silages could be obtained from green herbage of corn or sunflower alone, however their nutritive values could be improved if they are mixed at 50% ratio.

Key words: Corn, sunflower, mixture silages, silage quality, *in vivo* digestibility

INTRODUCTION

Silage type corn and sunflower produces high green herbage yield per area and if ensiled they provide nutritive and preferable wet feed for livestock (Kılıç,1986). While, McGuffey and Schingoethe (1980) reported that the nutritive value of sunflower silage was lower than that of corn silage, De Azambuja Ribeiro *et al*. (2002) and Garcia (2002) pointed out that higher CP and EE content of sunflower could compensate for this shortcoming of sunflower silage. Sunflower silage was similar to corn silage in silage fermentation quality, superior to namely protein content but inferior in nitrogen free extracts (Ray *et al*., 1921). Sunflower, in comparison to corn, provides high dry matter yield and has better resistance to both drought and cold (Gonçalves *et al*., 1999). High fiber content of sunflower silage causes decreases in digestibility of nutrient matters. The low DM content at harvesting stage generates difficult in ensiling, but these difficulties could be overcome by making corn/sunflower mixture silages with 1/3 ratio (Hoppe, 1997). Threfore, the study were to determine fermentation and digestibility characteristics of nutrients of corn, sunflower and corn-sunflower silages prepared at different mix ratios.

MATERIALS AND METHODS

Sunflower and corn harvested with a silo track at early dough stage of maturity were used as silage material. Green herbage of Sunflower (SF), corn (C) and corn-sunflower mixtures at different rates [75% corn+25% sunflower (75C25SF), %50 corn+%50 sunflower (50C50SF), 25% corn+75 sunflower (25C75SF)] were prepared on fresh material basis, tightly filled in plastic 120 l barrels (a total of 25, 5 replicate for 5 treatments), closed with lid and sealed. Then, barrels were turned upside down and placed for fermentation. Barrels were opened 90 days later and sampled for chemical analysis. The chemical composition of fresh material is given in Table 1. The pH of the silages was determined immediateley after silage liquid was obtained

Table 1: Chemical compositions (DM%) of fresh materials

	SF	C	25C75SF	50C50SF	75C25SF
DM	22.21	26.87	24.13	24.54	26.04
OM	88.70	94.54	91.25	91.07	93.59
CP[1]	2.79	1.61	2.12	1.92	1.69
EE	11.54	1.77	10.28	7.51	3.76
ADF	38.64	39.42	41.56	38.73	38.67
NDF	42.27	58.27	45.18	48.94	54.21

[1]In fresh material

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(Hart and Horn, 1987). Then the remaining silage fluid was filtered through Whatman 54 paper, centrifuged and stored at -20°C. Lactic, acetic, propionic and butyric acids in silage fluids were analyzed using high performance liquid chromatography (Muck and Dickerson, 1988).

The dry matter (DM), crude protein (CP), ether extract (EE) and ash analyses were done according to AOAC (1990). Crude protein analysis was done in wet samples. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were analysed according to Van Soest and Robertson (1979). The digestibiltity of silages was determined with conventional *in vivo* digestibility technique using 5 Akkaraman ram lambs (2 years old). PROC GLM in SAS/STAT (2007) was used for all data analysis. Mean treatment differences were determined by Duncan's multiple range test with a level of statistical differences of 5%.

Table 2: Chemical compositions, organic acid concentration (DM%) and crude nutrient matter digestitibility values % of different silages

Silages	SF	C	25C75SF	50C50SF	75C25SF	SEM
Chemical composition						
DM	21.17^{c}	25.96^{a}	23.01^{b}	23.31^{b}	25.48^{a}	0.17
OM	88.54d	93.51^{a}	90.28^{c}	91.94^{b}	92.50^{b}	0.10
CP[1]	1.74^{ab}	1.57d	1.92^{a}	1.72^{b}	1.60^{c}	0.04
EE	11.57^{a}	1.53d	10.60^{a}	7.37^{b}	3.60^{c}	0.18
ADF	37.56	38.38	41.26	37.61	38.44	0.63
NDF	40.97e	56.97^{a}	44.60d	48.22^{c}	53.88^{b}	0.45
pH	4.35^{a}	3.98c	4.20^{b}	4.14^{b}	4.14^{b}	0.02
Total organic acids (% of DM)						
Lactic acid	8.75^{a}	4.80^{c}	8.08^{a}	6.53^{b}	4.82^{c}	0.31
Acetic acid	1.89^{a}	1.21^{b}	2.07^{a}	1.77^{ab}	1.68^{ab}	0.21
Propionic acid	1.84^{a}	0.13^{c}	2.01^{a}	1.45^{b}	0.14^{c}	0.15
Butyric acid	0.61^{a}	0.14^{b}	0.20^{b}	0.30^{ab}	0.16^{b}	0.12
Digestibility (%)						
DM	59.34^{c}	62.36^{ab}	60.12^{bc}	61.58^{abc}	63.86^{a}	0.40
OM	59.38^{c}	64.99^{ab}	62.11^{bc}	64.28^{ab}	66.83^{a}	0.53
CP	55.27^{a}	44.74^{c}	50.07^{b}	43.23^{c}	47.02^{bc}	0.58
EE	92.62^{ab}	79.28^{c}	95.09^{a}	93.55^{ab}	91.31^{b}	0.43
ADF	39.19^{c}	56.55^{b}	46.25^{c}	51.71^{bc}	59.47^{a}	0.95
NDF	48.67^{c}	56.13^{a}	43.38^{c}	51.00^{b}	58.47^{a}	0.73

[1]In fresh material, a,b,c,d,e: Values with different superscripts in the same line differ significantly ($p<0.05$), SF: Sunflowers, C: Corn

RESULTS AND DISCUSSION

Dry matter content of C and 75C25SF silages were similar to each other and was higher than SF, 25C75SF and 50C50SF silages (p<00.5). The addition of the sunflower in to mixture decreased DM content of the mixed silages compared to corn silage but increased compared to sunflower silage ($p<0.05$). The highest OM and NDF contents were obtained form C silage ($p<0.05$) and OM and NDF contents of silages increased as the amount of the corn in the mixture increased ($p<0.05$). The lowest DM, OM and NDF contents were obtained form SF silage, whereas the lowest CP and EE contents were obtained from C silage ($p<0.05$). It was observed that DM, OM and NDF contents increased as the percentage of corn increased in silage prepared with a mixture of sunflower and corn ($p<0.05$; Table 2). There were no differences in ADF contents between silages. Likewise, Anil *et al*. (2000) reported that DM content of corn silage was higher, but EE, CP, ADF and NDF contents were were lower than that of corn-sunlfower mixed silages. ADF and NDF concentrations decrease as fat ratio increased in sunflower silage (Gonçalves *et al*., 1999; Immig and Pabst, 2000; Demirel *et al*., 2006b). Negative relationship of soluble carbohydrate content of silages with crude cellulose content and positive relationship with nitrogen free extract content have been reported (Kılıç, 1986; Ray *et al*., 1921).

CP content of SF silage was similar to that of 25C75SF and 50C50SF mixed silages, whereas higher than C and 75C25SF silages ($p<0.05$). No differences between SF and 25C75SF silages in EE content were found, whereas EE content of silages decreased as the corn ratio increased ($p<0.05$). CP and EE contents of the silages increased significantly with sunflower addition to the silages ($p<0.05$). Neutral detergent fiber content is lower than other silage in SF silage ($p<0.05$). It was observed that the increasing of amount of the corn in the mixture was arised DM, OM and NDF content of the mixed silages compared to SF silage ($p<0.05$). In general, as the increase of ratio of the sunflower in the mixture silages were appeared to an incresse in CP and EE contents in the mixed silages compared to C silage ($p<0.05$; Table 2). Similar to these findings, higher ADF, CP and EE contents of sunflower silage compared with corn silage have been reported (Undersander *et al*., 1990; Gregoire, 1999). Also De Azambuja Ribeiro *et al*. (2002), demonstrated that sunflower silage had 1.5-2 times higher cellulose and 3 times higher lignin contents than that of corn silage.

DM, ADF and NDF contents of the feed vary according to species, harvesting stage, cutting height, environmental conditions and differences in plant species in the mixture (Hart, 1990; Bolsen, 1996; İptaş and Avcıoğlu, 1997; Demirel *et al*., 2006a). Depending on the maturity stage, fat ratio increases and cell wall components (ADF and NDF) decrease related to this increase fat ratio (Gonçalves *et al*., 1999; Immig and Pabst, 2000). Sunflower silage contains more CP, EE and ADF depending on the variety than corn silage on a dry matter basis (McGuffey and Schingoethe, 1980; Tomich *et al*., 2004).

The mean pH value of SF silage was higher than that of C, 25C75SF, 50C50SF and 75C25SF silages and, C silage had the lowest pH value ($p<0.05$). Corn-sonflower mixed silages had lower pH than that of SF silage, but higher than C silage ($p<0.05$; Table 2). Silage pH values decreased parallel to the addition of corn levels in the mixtures compared to SF silage ($p<0.05$).

Silage quality is highly related to DM content of silage material ensiled. Low DM content of sunflower silages causes low pH value and, therefore it was suggested that DM in the silage should be increased (Kılıç, 1986; Immig and Pabst, 2000). It was reported that sunflower and corn-sunflower mix silages had higher pH than that of corn silage and as the sunflower ratio in the mixture increased the pH values of the silage increased (Anil *et al.*, 2000; Immig and Pabst, 2000; Demirel *et al.*, 2006a). pH values obtained in this study were within the range required for optimal silage fermentation (Kılıç, 1986; Alçiçek and Özkan, 1997).

Lactic acid was the important organic fermentation product in all types of silages and its amount in the silages was sufficient to assure adequate conservation. Fermentation products such as lactic, acetic, propiyonic and butyric acit concentrations were higher in sunflower silage compared with corn silage ($p<0.05$). Lactic, acetic and propionic acid concentrations in SF, 25C75SF and 50C50SF silages were higher than C and 75C25SF silages ($p<0.05$). Acetic acid contents of SF and 25C75SF silages were high according to C silage ($p<0.05$) and similar to 50C50SF and 75C25SF silages. Butyric acid in mixed silages decreased significantly as the ratio of sunflower decreases or ratio of corn in the mixture increased ($p<0.05$; Table 2).

Both pH and organic acid concentrations of silages are important quality criteria and in the present study they are within desired limits (Kılıç, 1986; Alçiçek and Özkan, 1997). The concentrations of organic acids of sunflower silage were higher than that of sorghum silage and the level of acids decreases parallel to the increases of sorghum levels in the mixtures (Demirel *et al.*, 2006a). It was reported that in addion to readily fermentable carbohydrates, protein content of the feed is also important in lactic fermentation (Kılıç, 1986; Çerçi *et al.*, 1997; Filya, 2000). Silage organic acids concentrations was affected with addition to readily fermentable feedstuffs, plant species and the ratio in the mixture (Demirel *et al.*, 2001ab, 2003). The presence of a positive relationship between volatile fatty acid formed in silages and fermentation quality, preventive effect of volatile fatty acits especially proprionic and butyric acids on aerobic mold and yeast formation in silages have been reported (Moon 1983).

DM, OM, ADF and NDF digestibilities of C silages were higher than those of SF silage ($p<0.05$), but similar to other mixed silages. DM digestibiliy of SF silage was lower than 75C25SF mixed silage ($p<0.05$), whereas similar to other mixed silages. OM digestibility of SF silage was similar to 25C75SF mixed silage but lower than other mixed silages ($p<0.05$). CP digestibility of C silage was lower than SF silage and 25C75SF mixed silage ($p<0.05$). There was a decrease in CP digestibility as corn ratio increased in mixed silages compared with SF silage ($p<0.05$). EE digestibility of C silage was lower than other silages ($p<0.05$). There were no differences between SF silage and mix silages in EE digestibility. ADF and NDF digestibility of C silage was higher than that of SF silage ($p<0.05$). There was a decrease in ADF and NDF digestibility as sunflower ratio increased in mixed silages compared with C silage ($p<0.05$; Table 2).

Total digestibilities of nutrients in sunflower silages have been reported be lower than that of corn silage (Hoppe, 1997). Anil *et al.* (2000) reported that DM, OM, ADF and NDF digestibilities of sunflower-corn mix silages was lower compared with corn silage, but digestibility of CP was higher. DM digestibilities in sunflower-corn mix silages desresed as cell wall components increased, CP protein digestibility incresed as CP content in the plant increased (Nocek and Russell, 1988; Immig and Pabst, 2000). It was reported that DM digestibility was not affected from the decrease in NDF digestibility (Jaurena and Pichard, 2001), instead, the decrease in DM and OM digestibility arised from the increase in ADF and NDF content or their low digestibility (Anil *et al.*, 2000). No differences between corn and corn-sunflower mix silages in DM, NDF and ADF digestibilities have been reported (Valdez *et al.*, 1988 a,b). It reported that the digestibilities of DM, CP and EE of sunflower silages were higher and, digestibilities of ADF and NDF were lower compared with sorghum silages. Digestibilities of EE and CP increased with increasing levels of sunflower in the mixtures whereas digestibility ADF and NDF decreased (Demirel *et al.*, 2006a). Digestibility of the sunflower silage is expected to be low beacuse of its high fiber content; nevertheless, its high fat content compensates this shortcoming (McGuffey and Schingoethe, 1980). Negative correlation of readily soluble carbohydrate with crude cellulose content but positive correlations with nitrogen free exract have been reported (Özen *et al.*, 1993).

Digestibility is high in immature plants because of their lower lignification and therefore NDF digestion is a criterion for quality of roughage (Oba and Allen, 1999; Bal *et al.*, 1997).

CONCLUSION

In conclusion, silage fermentation properties and digestibility of nutrients indicate that high quality silages could be obtained from green herbage of corn, sunflower alone or sunflower-corn mixture. However it was concluded that low digestibility of sunflower silage because of their high cell wall componets could be overcome by increasing corn content in the mixture. High digestibilities of some nutrients in sunflower silage could be reflected in mix silages and therefore 50% ratio sunflower-corn mixture may produce very desirable results in terms of silage property and digestibities of nutrients.

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