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Nutritive Value of Sunflower Silages Ensiled with Corn or Alfalfa at Different Rate

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ABSTRACT

Sunflower (*Helianthus annuus* L.) having shorter growing season, better cold tolerant and more drought resistant is important alternative silage plant in highlands. But it has poor silage quality. To improve the quality of sunflower silage can be mixed an appropriate amount of corn (*Zea mays* L.) and alfalfa (*Medicago sativa* L.). This research was carried out to evaluate quality characteristics of nine silage types: Sunflower, corn and alfalfa silages; plus their some mixtures silages (75% sunflower + 25% corn, 50% sunflower + 50% corn, 25% sunflower + 75% corn, 75% sunflower + 25% alfalfa, 50% sunflower + 50% alfalfa and 25% sunflower + 75% alfalfa); at two harvest stages: Beginning of flowering for sunflower and alfalfa and milk-dough stage for corn (early stage), and end of flowering stage for sunflower and alfalfa, and dough stage for corn (late stage). The experimental design was in a factorial arrangement of randomized complete block with replicated four times. Dry matter content (DM), crude protein content (CP), neutral detergent fiber content (NDF), acid detergent fiber content (ADF), silage pH and physical characteristics (PC) of silages were determined in this study. Mixing of alfalfa in NDF, ADF and CP and corn in DM, pH and PC had positively effect in sunflower silages. Late stage had positively affected DM, PC and pH for silage. Consequently, sunflower silages mixed with corn, with the condition of not being less than 50% at late stage, are recommended for farmers.

Keywords: Sunflower; Corn; Alfalfa; Mixtures; Silage

Farklı Oranlarda Yonca veya Mısır ile Karıştırılan Ayçiçeği Silajının Besin Değeri

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ÖZET

Kısa gelişme süresine sahip, soğuğa ve kurağa dayanıklılığı iyi olan ayçiçeği (*Helianthus annuus* L.), önemli bir alternatif silaj bitkisidir. Fakat ayçiçeğinin silaj kalitesi düşüktür. Ayçiçeği silajının kalitesini iyileştirmek için mısır

(*Zea mays* L.) ve yonca (*Medicago sativa* L.) ile karışımlar yapılabilir. Bu çalışmada ayçiçeği, mısır ve yonca ile bunların bazı karışımlarından oluşan (% 75 ayçiçeği + % 25 mısır, % 50 ayçiçeği + % 50 mısır, % 25 ayçiçeği + % 75 mısır, % 75 ayçiçeği + % 25 yonca, % 50 ayçiçeği + % 50 yonca ve % 25 ayçiçeği + % 75 yonca) silajların kalite özellikleri incelenmiştir. Silajlar bitkilerin iki farklı gelişme döneminde (Erken dönem: Yonca ve ayçiçeği için çiçeklenme başlangıcı, mısır için süt olum dönemi ve Geç dönem: Yonca ve ayçiçeği için çiçeklenme sonu, mısır için hamur olum dönemi) yapılmıştır. Araştırma şansa bağlı tam bloklar deneme deseninde faktöriyel düzenlemeye göre dört tekrarlamalı olarak kurulmuştur. Silajların kuru madde oranı (DM), ham protein (CP), NDF, ADF, pH ve fiziksel özellikleri (PC) incelenmiştir. Ayçiçeği ile yonca karışımlarında NDF, ADF ve CP; mısır karışımlarında ise DM, pH ve PC yüksek bulunmuştur. Geç dönemde silaj yapıldığı zaman DM, PC ve silaj pH'sı yükselmiştir. Bu nedenle üreticilere geç gelişme döneminde ayçiçeğinin mısır ile en az % 50 oranında zenginleştirilerek silolanması tavsiye edilebilir.

Anahtar Kelimeler**:** Ayçiçeği; Mısır; Yonca; Karışım; Silaj

1. Introduction

There are some problems for meeting roughage requirements of farms in Eastern Turkey during long the winters (Tavlas et al 2009). Main reasons of this problem are low forage crops cultivation and productivity (Yolcu & Tan, 2008). Far a partial solution to this problem, silage crops growing were started in this region, since main silage crops such as corn, sunflower and sorghum produce higher dry matter yield when compared to the other forage crops for animal feeding (Guney et al 2012).

Sunflower has more tolerant to cold and drought conditions (Ozduven et al 2009) and it is less affected by frost conditions, remains longer time in the field and completes the its growing period (Guney et al 2012). Besides, sunflower has higher dry matter yield and crude protein content than that of corn (Mafakher et al 2010). However, sunflower silage has some negative features in terms of quality. The high fiber content of sunflower silage causes decreases digestibility of nutrient matters (Demirel et al 2008) and its low dry matter content at maturity stage create ensiling difficulties (Peiretti & Meineri 2010). Besides, sunflower silage has higher pH (Demirel et al 2008; Mafakher et al 2010) and lower quality in terms of color, structure and smell (Guney et al 2012).

Mixtures in different rates among various silage plants not only increase silage quality but also decrease negative properties in silages. Thus, many investigations have been made related to the topic by many researchers in recently (Demirel et al 200; Zhu et al 2011; Souma et al 2011). In addition, determination of suitable harvest stages of plants used for silage also are important to increase silage quality. Influences of plants harvest stages on silage quality have been reported by many researchers (Bal et al (1997); Demirel et al 2006a; De Rezende et al 2007; Morales et al 2011).

To decrease some negative features of sunflower silage can be added the other plants such as corn and alfalfa to the silage. However, which plants and what portions to be mixed up should be known. Moreover, farmers want to know suitable harvest stages of these plants for making quality silage. Consequently, both silage types and harvest stages of plants are important factors for obtaining quality silages. For these reasons, the aim of this study was to evaluate quality characteristics of nine silage types at two different harvest stages.

2. Material and Methods

The study was carried out under laboratory conditions at the Field Crops Department in Ataturk University, Agriculture Faculty, in 2012. The experimental design was completely in a factorial arrangement of randomized complete block with replicated four times and treatments were nine silage types: Sunflower (*Helianthus annuus* L., population) (SF), corn (*Zea mays* L. var. OSSK-596) (C) and alfalfa (*Medicago sativa* L. var. Bilensoy) (A) pure, and 75% sunflower + 25% corn (75SF-25C), 50%

sunflower + 50% corn (50SF-50C), 25% sunflower + 75% corn (25SF-75C), 75% sunflower + 25% alfalfa (75SF-25A), 50% sunflower + 50% alfalfa (50SF-50A), 25% sunflower + 75% alfalfa (25SF-75A) silages and two different stages beginning of flowering for sunflower and alfalfa, and milk-dough stage for corn (early stage), and end of flowering stage for sunflower and alfalfa, and dough stage for corn (late stage). Rates of sunflower binary mixtures enriched with corn and alfalfa were determined according to weight. Sunflower, corn and alfalfa were chopped and then ensiled alone or mixture into 2.5 kg glass jars and four glass jars were made for each silage sample. Silages were opened to analyze for dry matter content (DM), crude protein content (CP), neutral detergent fiber content (NDF), acid detergent fiber content (ADF), silage pH and physical characteristics (PC) of silages after 60 days of ensiling. Dry matter content was found according to AOAC (1990). The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigswinter, Germany) were used to determine total N (Bremner 1996) in single plants and binary mixtures silages. ADF, NDF and pH measurements of single plants and binary mixtures silages were found according to Akyildiz (1986), Kilic (1986) and Van Soest (1963). Physical characteristics (color, structure and smell) were determined by the Kilic's (1986) method.

Data of DM, CP, ADF, NDF, pH and PC were subjected to analysis of variance (ANOVA). The results were statistically evaluated by using MSTAT-C statistical computer package software program and mean separations were made on the basis of least significant differences test (LSD).

3. Results and Discussion

Significant differences ($P < 0.01$) were found in terms of DM among silage types at early stage, late stage and over harvest stages (Table 1). Similar DM variation among silage types were shown by other researchers (Demirel et al 2006b; Demirel et al 2008; Contreras-Govea et al 2009).

The higher dry matters were obtained from pure C silage (27.42%), followed by pure A (24.44%), 50SF-50A (23.91%) and 25SF-75C (23.90%) silages at early stage. The higher dry matters among silage types were found in pure C silages (32.58%) followed by 25SF-75C (31.79%) and 50SF-50C (31.25%) silages at late stage. Significant differences were determined among silage types over harvest stages. Corn silage had the highest DM (30.00%) followed by 25SF-75C (27.85%) silages, whereas all the other silages gave similar DM over harvest stages. Dry matter contents of grasses are higher than those of legumes and sunflower (Guney et al 2012; Dumlu & Tan, 2009). Therefore, dry matter contents were found as high value in a pure corn silage and mixtures silage that have high rate corn. There was difference ($P < 0.01$) among harvest stages in terms of the DM over silage types. This is in agreement with the results of Bal (2006), Demirel et al (2006a) and De Rezende et al (2007), who reported that harvest times affected DM of silages. Late stage gave higher DM (29.13%) than that of early stage (22.96%) (Table 1). It is an expected

Table 1- Dry matter contents of sunflower silages enriched with corn and alfalfa at different growth stages (%)

Çizelge 1- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının kuru madde oranları (%)

Silage type	*Early stage[a]*	*Late stage[b]*	*Mean*
Sunflower (SF)	21.13 bc	27.97 bc	24.55 c
75SF-25C	19.71 c	30.14 ab	24.93 c
50SF-50C	21.81 bc	31.25 a	26.53 bc
25SF-75C	23.90 b	31.79 a	27.85 b
Corn (C)	27.42 a	32.58 a	30.00 a
75SF-25A	21.14 bc	28.26 bc	24.70 c
50SF-50A	23.91 b	27.11 c	25.51 c
25SF-75A	23.17 bc	27.54 bc	25.35 c
Alfalfa (A)	24.44 ab	25.57 c	25.01 c
Mean	22.96 b	29.13 a	26.05
Silage type x harvest stage interaction LSD: 3.61**			

Values followed by different letters in a column represent significant differences; **, P< 0.01; a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

result that dry matter contents increase with the advancement of ripening in plants. Silage type x harvest stage interaction was important in DM. This relation was shown in Figure 1.

There were significant differences in terms of CP content among silage types at early stage ($P < 0.01$), late stage ($P < 0.05$) and over harvest stages ($P < 0.01$) (Table 2). Similar findings were also reported in terms of CP among different silage types in other studies (Demirel et al 2006b; Demirel et al 2008; Mafakher et al 2010). Pure alfalfa silage and SF silages enriched with A produced higher CP content than the other silages at early stage, late stage and over harvest stages. Pure alfalfa, 50SF-50A, 75SF-25A and 25SF-75A silages gave 17.95, 16.57, 16.55 and 15.94% CP content at early stage, respectively. Also at late stage, pure A silage (14.58%), 25SF-75A (15.47%), 50SF-50A (14.37%) and 75SF-25A (12.95%) silages had greater CP content than the other silages. Likewise, pure A silage, 25SF-75A, 50SF-50A and 75SF-25A silages produced 16.27, 15.70, 15.47 and 14.75% CP content over harvest stage, respectively. It is an expected result that silage of alfalfa legume had greater crude protein content than corn and sunflower silages. Therefore, crude protein contents of silages including alfalfa were high.

Differences ($P < 0.01$) were determined among harvest stages in terms of CP content over silage types. This result is in agreement with statement of De Rezende et al (2007), reported that sunflower cultivars harvested at 95-110 days after sowing had differences in terms of CP. Moreover, Bal (2006) determined that whole plant corn silages harvested at 3 different stages of maturity had differences in terms of CP. Early stage (14.32%) had higher CP content than that of late stage (12.58%) over silage type (Table 2).

ADF and NDF contents of the silage types were significantly ($P < 0.01$) different at early stage, late stage and over harvest stages (Table 3 and 4). Similarly, Contreras-Govea et al (2006), Contreras-Govea et al (2009) and Guney et al (2012) found that different silage types had

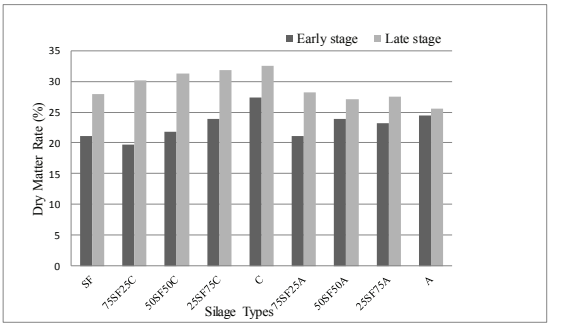

Figure 1- Silage type x growth stage interaction in dry matter content of sunflower silages enriched with corn and alfalfa at different stages

Şekil 1- Silaj tipi x gelişme dönemi interaksiyonunun mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarında kuru madde oranına etkileri

Table 2- Crude protein contents of sunflower silages enriched with corn and alfalfa at different stages (%)

Çizelge 2- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının ham protein oranları (%)

Silage type	*Early stage[a]*	*Late stage[b]*	*Mean*
Sunflower (SF)	13.54 c	11.60 cd	12.57 c
75SF-25C	13.46 c	12.66 c	13.06 c
50SF-50C	13.74 bc	12.49 c	13.12 c
25SF-75C	10.97 d	10.11 de	10.54 d
Corn (C)	10.16 d	9.04 e	9.60 d
75SF-25A	16.55 a	12.95 bc	14.75 b
50SF-50A	16.57 a	14.37 ab	15.47 ab
25SF-75A	15.94 ab	15.47 a	15.70 ab
Alfalfa (A)	17.95 a	14.58 a	16.27 a
Mean	14.32 a	12.58 b	13.45
Silage type x harvest stage interaction: ns			

Values followed by different letters in a column represent significant differences; ns, no significant; a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

variation in terms of ADF and NDF. In addition, Demirel et al (2008) reported that silage types had differences in NDF. Pure alfalfa silage produced the lowest ADF content (26.94%) followed by

pure C silage (28.65%) and 25SF-75A (28.69%) at early stage (Table 3). Also at late stage, pure alfalfa (29.88%), pure C (31.80%), 25SF-75A (32.56%) and 50SF-50A (33.32%) silages had the lower ADF contents than the others. Similarly, the lowest ADF content was found pure A silage (28.41%) followed by pure C silage (30.23%) and 25SF-75A silage (30.62%), whereas the other silages gave the highest ADF content over harvest stages. Pure alfalfa (41.73%), 25SF-75A (48.35%) and 50SF-50A (50.27%) silages contained lower NDF than other silages at early stage (Table 4). Also at late stage, pure alfalfa silage (43.19%), 25SF-75A (50.43%) and 50SF-50A (51.91%) silages included the lower NDF contents than those of the others. Similarly, the lowest NDF content was found pure A silage (42.46%) followed by 25SF-75A (49.39%) and 50SF-50A (51.09%) silages, whereas the other silages had similar or higher NDF contents over harvest stages. Harvest stages had different ($P < 0.01$) in terms of ADF and NDF contents over silage types. This result is in agreement with the report of Demirel et al (2006a), who stated that sunflowers harvested at different stages had variation in terms of ADF and NDF. AF and NDF contents of the early stage were lower than those of the late stage (Table 3 and 4). This is a natural consequence of the increase fiber structure with increasing maturity in plants.

Significant variation had among the silage types in terms of silage pH at early stage ($P < 0.01$) late stage ($P < 0.01$) and over harvest stages ($P < 0.01$) (Table 5). Similarly, Demirel et al (2006b), Demirel et al (2008) and Mafakher et al (2010) reported that there were differences in terms of pH among different silage types. Pure corn silage and SF silages mixtured C had the lower pH than those of the others at early stage and late stage. Silage pH of pure C, 50SF-50C, 25SF-75C and 75SF-25C silages were resulted in 4.36, 4.38, 4.47 and 4.92

Table 3- Acid detergent fiber contents of sunflower silages enriched with corn and alfalfa at different stages (%)

Çizelge 3- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının ADF oranları (%)

Silage type	*Early stage*[a]	*Late stage*[b]	*Mean*
Sunflower (SF)	37.81 a	43.09 a	40.44 a
75SF-25C	34.28 bc	38.21 b	36.24 b
50SF-50C	32.13 cd	36.21 bc	34.17 c
25SF-75C	31.59 c-e	34.42 cd	33.01 c
Corn (C)	28.65 ef	31.80 ef	30.23 d
75SF-25A	35.20 ab	38.56 b	36.88 b
50SF-50A	31.82 cd	33.32 de	32.57 c
25SF-75A	28.69 ef	32.56 d-f	30.62 d
Alfalfa (A)	26.94 f	29.88 f	28.41 e
Mean	31.90 b	35.34 a	33.62
Silage type x harvest stage interaction: ns			

Values followed by different letters in a column represent significant differences; ns, no significant; a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

Table 4- Neutral detergent fiber contents of sunflower silages enriched with corn and alfalfa at different stages (%)

Çizelge 4- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının NDF oranları (%)

Silage type	*Early stage*[a]	*Late stage*[b]	*Mean*
Sunflower (SF)	55.85 a	57.62 a	56.73 a
75SF-25C	54.14 ab	55.75 a-c	54.94 a
50SF-50C	52.32 bc	53.00 c-e	52.66 b
25SF-75C	51.89 bc	53.47 cd	52.68 b
Corn (C)	52.07 bc	53.65 b-d	52.86 b
75SF-25A	55.45 a	56.36 ab	55.91 a
50SF-50A	50.27 cd	51.91 de	51.09 bc
25SF-75A	48.35 d	50.43 e	49.39 c
Alfalfa (A)	41.73 e	43.19 f	42.46 d
Mean	51.34 b	52.82 a	52.08
Silage type x harvest stage interaction: ns			

Values followed by different letters in a column represent significant differences; ns, no significant; a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

pH at early stage and 4.12, 4.23, 4.28 and 4.69 pH at late stage, respectively. Similarly, also over harvest stages, pure C (4.24), 50SF-50C (4.30), 25SF-75C (4.38) and 75SF-25C (4.80) had lower pH than those of the others. Silage pH in pure corn silage and mixture silages that have a high rate of corn were found in low value due to corn containing more dry matter content and soluble carbohydrate. Among harvest stages, there were also differences in pH over silage types (Table 5). This result is in agreement with reports of Demirel et al (2006a), Bal (2006) and De Rezende et al (2007), who stated that there were differences in terms of silage pH among harvest stages. Late stage had lower pH (4.74) than that of early stage (5.13). Because accumulation of soluble carbohydrates increased with maturity advancement, fermentation may be easy at late stage. Eventually, silage pH might be decrease at late stage in the research.

Silages in terms of quality determining according to physical characteristics had important variation at early stage and late stage (Table 6). The greatest quality was found in a pure C silage (Supreme) followed by 25SF-75C (Medium), 50SF-50C (Low), 75SF-25A (Low), 75SF-25C (Low) and 50SF-50A (Low) at early stage. Similarly, also at late stage, the highest quality was determined in pure C silage (Supreme) followed by 25SF-75C (Good) and 50SF-50C (Medium). The other silages were low quality.

Table 5- Silage pH of sunflower silages enriched with corn and alfalfa at different stages

Çizelge 5- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının pH değerleri

Silage type	*Early stage*[a]	*Late stage*[b]	*Mean*
Sunflower (SF)	5.32 a-c	4.83 a-c	5.08 bc
75SF-25C	4.92 c	4.69 bc	4.80 c-e
50SF-50C	4.38 c	4.23 c	4.30 e
25SF-75C	4.47 c	4.28 c	4.38 de
Corn (C)	4.36 c	4.12 c	4.24 e
75SF-25A	5.19 bc	4.85 a-c	5.02 b-d
50SF-50A	5.23 a-c	5.10 ab	5.17 bc
25SF-75A	6.27 a	5.50 a	5.88 a
Alfalfa (A)	6.04 ab	5.09 ab	5.56 ab
Mean	5.13 a	4.74 b	4.94
Silage type x harvest stage interaction: ns			

Values followed by different letters in a column represent significant differences; ns, no significant; a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

Table 6- Physical characteristics (color, smell and structure) of sunflower silages enriched with corn and alfalfa at different stages

Çizelge 6- Değişik gelişme dönemlerinde mısır veya yonca ile zenginleştirilmiş ayçiçeği silajlarının fiziksel özellikleri (renk, koku ve doku)

Silage type	*Early stage*[a]					*Late stage*[a]				
	Color	*Smell*	*Structure*	*Total*	*Quality*	*Color*	*Smell*	*Structure*	*Total*	*Quality*
SF	0	2	2	4	Bad	0	4	3	7	Low
75SF-25C	1	3	2	6	Low	1	4	3	8	Low
50SF-50C	1	4	4	9	Low	2	6	4	12	Medium
25SF-75C	1	8	4	13	Medium	2	8	4	14	Good
C	2	14	4	20	Supreme	2	14	4	20	Supreme
75SF-25A	1	4	3	8	Low	2	4	3	9	Low
50SF-50A	0	3	2	5	Low	2	4	3	9	Low
25SF-75A	0	2	2	4	Bad	1	3	3	7	Low
A	0	2	1	3	Bad	0	3	3	6	Low

a, beginning of flowering stage for sunflower and alfalfa and milk-dough stage for corn; b, end of flowering stage for sunflower and alfalfa and dough stage for corn

4. Conclusions

Since the quality of silage types changes according to the harvest stage of plants used for silage, ideal harvest stages should be determined first in the results. In spite of the fact that late stage had higher ADF and NDF and lower CP than the early stage, it was found to be more appropriate because of greater DM and better physical characteristics, and lower pH for quality silage. Superiority of corn silage was apparent according to the results of the research. But, our aim in this study was to increase quality of sunflower silage with the addition of plants such as corn and alfalfa. In this context, while sunflower silages enriched with alfalfa were superior in terms of ADF, NDF and CP, sunflower silages enriched with corn had superior properties in DM and physical characteristics. Additionally sunflower silages mixed with alfalfa have high silage pH, it is not desirable. Consequently, sunflower binary mixtures silages enriched by corn with a condition of not being less than fifty percent at late stage, can be preferred for animal feeding in the regions where there are problems in corn cultivation.

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