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Research Article

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Silage, sunflower, landraces, silage quality

The Effect of The Harvest Stages and Additives on The Silage Value of The Different Sunflower Populations

Abstract

The research was carried out in the irrigated trial areas of Atatürk University Faculty of Agriculture in 2009 and 2010. 7 different local sunflower varieties (Edirne-black-seeded, Edirne-white-seeded, Erzurum-black-seeded, Erzurum-white-seeded, Kırklareli-black-seeded, Kırklareli white-seeded and Tekirdağ) from 3 different harvest times (table formation, full flowering and seed filling) were examined for silage. In the study, silage was carried out using 5 different additives (additive-control, 10% barley, 10% straw, 5% molasses, 1% salt). Dry matter ratio, crude protein ratio, ADF ratio, NDF ratio, relative feed value and pH values were determined in silage. The results showed that local varieties, form times and additives have important effects on silage quality of sunflower. Using barley and molasses as additives significantly improves silage quality. Although the delay in form time decreased the crude protein ratio and increased the ADF and NDF ratios, it improved the dry matter ratio and silage pH.

INTRODUCTION

In regions such as the Eastern Anatolia Region where the continental climate is dominant and winters are long and snowy, animals have to be fed in shelters. Growing silage plants and expanding silage feeding are of great importance in this regard. The most preferred plant in silage making is corn (*Zea mays* L.). Silage making is widespread in the farming areas where corn is mainly produced. In the Eastern Anatolia Region, due to the high altitude, low temperatures and short growth period, at least 90 days of non-frost safe period required for corn cultivation cannot be provided every year. Therefore, it is useful to study alternative silage plants. Sunflower (*Helianthus annuus* L.) is one of the alternative silage plants because short vegetation period does not lead to a problem for sunflower. Their vegetation period until harvest maturity is quite short (Kılıç, 1986). It is resistant to drought and can be grown without watering in arid areas (Arioglu, 2000). It is more tolerant to climate stresses such as coldness, heat and drought. Therefore, the risk of frost damage suffered by corn in autumn is lower (Güney, 2006). For all these reasons, sunflower can be considered as an alternative silage plant in Erzurum and similar ecologies where corn farming is atrisk. However, thick sunflower stems and high lignin accumulation decrease the feed quality. Therefore, the harvest time of silage sunflower must be determined. This study was carried out to determine suitable silage sunflower genotypes and appropriate harvest periods for Erzurum and similar ecologies.

MATERIAL and METHODS

The research was carried out in 2009 as a field experiment and repeated in 2010 as a laboratory experiment. The field stage of the research was carried out at the Atatürk University Plant Production Application and Research Center irrigable trial area. In this study, 7 different confectionery local genotypes were examined and identified according to their place of origin. Confectionery landraces which have the characteristics of population are mostly preferred since their vegetative components are produced more (Güney, 2006) (Table 1).

Table 1. Sunflower landraces used in the study and their locations

Landrace	Place of origin
Erzurum-1 (White-seed)	Pasinler-Erzurum
Erzurum-2 (Black- seed)	Pasinler-Erzurum
Edirne-1 (White seed)	Keşan-Edirne
Edirne-2 (Black seed)	Keşan-Edirne
Kırklareli-1 (White seed)	Merkez-Kırklareli
Kırklareli-2 (Black seed)	Merkez-Kırklareli
Tekirdağ (Black seed)	Malkara-Tekirdağ

Sunflower populations were cultivated in May 2009 and 2010 and harvested in August each year. The study consisted of 7 different landraces (populations) and 3 different harvest times. Each landrace was harvested in 3 different developmental stages (R1: Table forming (H1), R6: Full blooming (H2) and R8: Seed filling (H3)). 21 different materials (7 landraces x 3 developmental stages) obtained from the field experiment were chopped in a laboratory type silage machine and silage was made by squeezing them in 2 kg glass jars. During silage making, 5 different additives (control, 10% barley, 10% straw, 5% molasses, 1% salt) were used and the silages were opened 2 months later. The laboratory experiment was conducted in randomized complete block design with three replications. Accordingly, a total of 315 applications (7 landraces x 3 developmental stages x 5 additives x 3 replications) were included in the laboratory trial. Dry matter ratio, crude protein ratio, ADF, NDF, silage pH and relative feed value (RFV) were investigated to determine the effects of additive and harvest times in local sunflower varieties (Akyıldız, 1986; Kılıç, 1986; Rohweder et al., 1978). The data obtained were subjected to variance analysis in the MSTAT-C package program and presented as a two-year average. The differences among the applications were identified and lettered according to the LSD Multiple Comparison Test. Interactions which were found to be significant were explained through graphics.

RESULTS and DISCUSSION

Dry matter ratio

Tekirdağ (23.66%) and Erzurum-white-seed (23.48%) populations constituted the group with the highest dry matter ratio. Erzurum (black) had the lowest dry matter ratio (22.20%) (Table 2). The reason for this difference in dry matter proportion of populations is that the amount of dry matter which sunflower populations can produce due to their genetic capacity is different. In similar studies conducted using sunflower, dry matter ratios differed as well (Güney, 2012; Goncalves et al., 1999; Noguera et al., 2006). The effect of the maturation period of the plant on dry matter rate is high and was found statistically significant. In the early harvest, it is reported that the plants are rich in water, poor in carbohydrates and the rate of dry matter decreased, while the ratio of dry matter increases and the silo ability of the feed increases by shifting the harvest towards the dough stage (Comberg, 1974; McDonald et al., 1991). As it can be seen from Table 2, as the harvest period progresses, the dry matter ratio of the silage materials obtained increased. As a matter of fact, while the rate of dry matter in the control plots was 18.72% in the table formation (H1) period, it was recorded as 21.43% in the flowering period (H2) and 28.83% in the seed filling period. Çelik (2009) examined the dry matter ratios of sunflower silage materials during the periods of flowering, dough and soft-dough stage and obtained the values 21.21%, 22.57% and 31.20% respectively. The dry matter ratio of silages without additives was determined as 20.09%. The highest dry matter ratio (28.14%) was found in silage with added straw, followed by barley (24.23%) and salt (21.24%) additives, respectively. The lowest dry matter ratio (21.15%) among additive silages was found in molasses, which is statistically higher than the control silages. In this study, additive application generally increased the ratio of dry matter. The additives (barley folded, salt, molasses and straw) applied were used for the purposes of increasing fermentation by using carbohydrate additives, preventing the growth of unwanted microorganism and increasing dry matter ratio. Similarly, Türemiş et al. (1997) found that grain folded, molasses and urea additives increase the dry matter ratio in alfalfa silage. In the study conducted by Gürbüz et al. (2004), the highest dry matter (34.48%) was determined in 5% barley folded + barley – vetch silage. It is emphasized in similar studies that straw is the application that increases dry matter ratio the most because it is a material with high structural substance ratio (Yalçınkaya et al., 2012).

Table 2. Dry matter, crude protein ratios and pH values of silage of sunflower populations harvested and ensiled with different additives at different development stages[1]

Population	Dry matter (%)	Crude protein (%)	pH
Edirne (black seed)	22.72 BC	11.13	4.52
Edirne (White seed)	22.97 AB	11.47	4.50
Erzurum (black seed)	22.20 C	11.74	4.55
Erzurum (white seed)	23.48 A	11.82	4.53
Kirklareli (black seed)	22.72 BC	11.10	4.54
Kırklareli (white seed)	23.04 AB	11.54	4.52
Tekirdag	23.66 A	11.50	4.51
Harvest Time			
Table Formation (H1)	18.72 C	12.72 A	4.66 A
Full Flowering (H2)	21.43 B	11.51 B	4.48 B
Seed Filling (H3)	28.83 A	10.17 C	4.44 B
Additives			
Control	20.09 D	11.55 BC	4.74 A
Salt	21.24 C	11.41 C	4.44 B
Molasses	21.15 C	11.87 B	4.53 B
Barley Folded	24.23 B	12.48 A	4.48 B
Straw	28.14 A	10.04 D	4.44 B
Average	22.97	11.47	4.52
F-test (LSD value)			
Population	** (0.73)	** (0.37)	ns
Additives	** (0.62)	** (0.32)	** (0.13)
Harvest Time	** (0.47)	** (0.24)	** (0.10)
PXA	** (1.63)	** (0.84)	ns
PXHT	** (1.26)	** (0.65)	ns
AXHT	** (1.06)	ns	* (0.23)

[1]Averages marked with capital letters are different at 1% level. * It shows significance at 0.05 level, **: 0.01 level.

The reactions of populations to the additives used in differed from one another. This situation caused the contribution x population interaction to be statistically significant (p <0.01). Straw is the additive material which has the highest dry matter for every population (Figure 1).

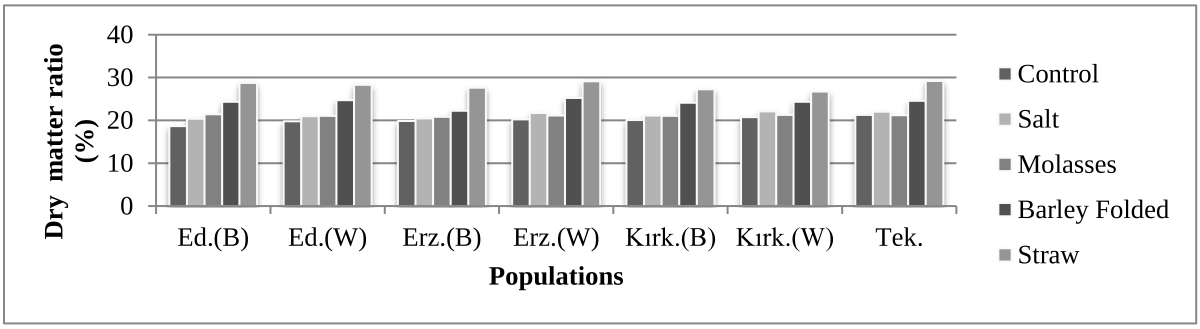

Figure 1. Change of dry matter ratio in sunflower silage according to populations and additives (additive x population interaction)

As the maturity period progressed, the dry matter ratio increased in all of the silage materials belonging to the sunflower plant harvested in different maturity periods. This is valid for all silages with and without additives. However, as the harvest period is delayed, this increase in dry matter ratio is different for each contribution (Figure 2).

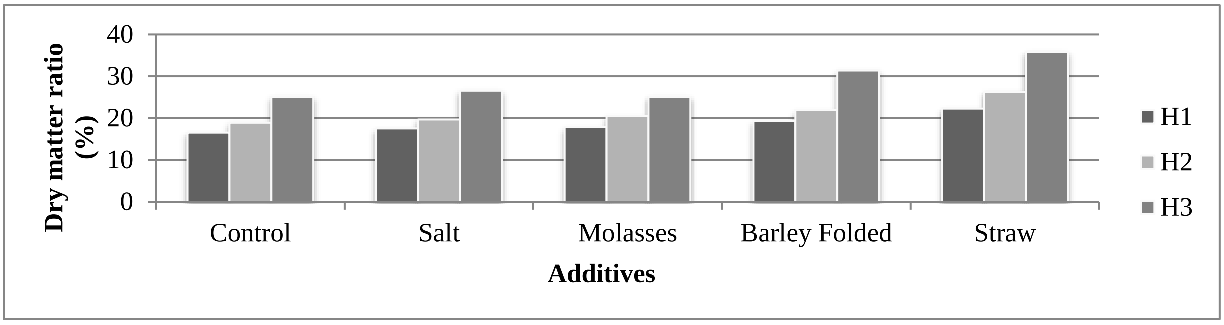

Figure 2. Change of dry matter ratio according to additive and harvest times in sunflower silage (additive x harvest time interaction)

It is a well-known fact that the accumulation of dry matter increases with the advancement of maturity in the plant. As can be seen from Table 2, this happens in all populations. As the harvest period is delayed, dry matter ratio of the populations increased and the increase in each population was different. This situation caused population x harvest time interaction to be statistically significant (Figure 3).

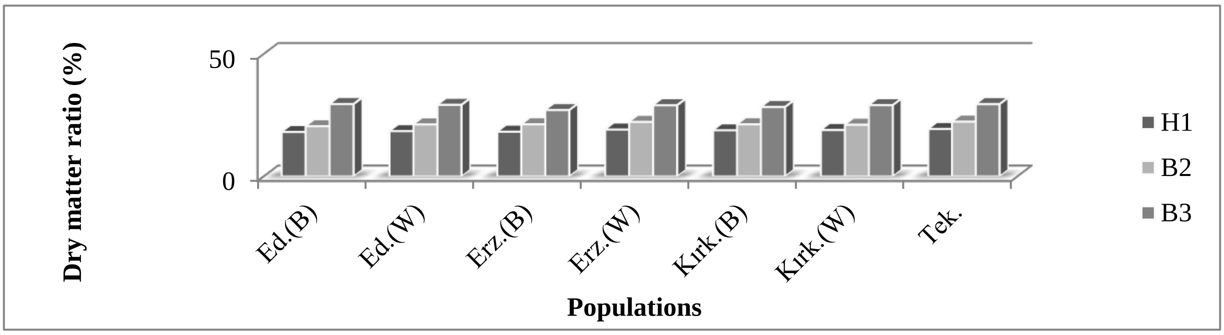

Figure 3. Change of dry matter ratio in sunflower silage according to population and harvest times (population x harvest time interaction)

Crude protein ratio

Crude protein ratios differed among populations and were statistically significant (Table 2). Erzurum populations (11.74% and 11.82%), white-seeded Kırklareli population (11.54%), white-seeded Edirne population (11.47%) and Tekirdag population (11.50%) constituted the group with the statistically highest rates of raw protein (Table 2). The lowest crude protein content was observed in the black-seeded Kırklareli (11.10%) population. The crude protein ratios of plants emerge as a result of the genetic structure and developmental state. Since very different genotypes were used in this study, crude protein ratios were found to be significantly different. Many researchers conducting studies to investigate different plants point to similar results (Güney et al., 2012; Gonçalves et al., 1999; Karadoğan and Akgün, 2009a). In the study, the crude protein ratio decreased due to the delayed harvest time (Table 2). The ratio of crude protein, which was in the table formation period (H1) 12.72%, decreased to 11.51% in the flowering period and 10.17% in the seed filling period. Plants in early developmental stage synthesize more protein due to the excess of photosynthesis surfaces and hence the raw protein contents are also high. With the advancement of development, crude cellulose production, which is the basic building material of the cell walls, increases, whereas the content of crude protein decreases due to the declinein photosynthesis areas (Geren et al., 2003). Our findings are also consistent with the results of many researchers who reported that the crude protein rate decreased with the progress of harvest time (Gonçalves et al., 1999; Noguero et al., 2006). The effects of the additives used in thisstudy on the crude protein ratio were different from one another (Table 2). The crude protein ratios of additive and salt added silages were very close to each other and were found to be 11.55% and 11.41%, respectively. Molasses additive slightly increased the rate of crude protein (11.87%), while barley foldedsignificantly increased the additive (12.48%). When straw was added to the silage, the crude protein ratio significantly decreased (10.04%) (Table 2). The crude protein ratio in barley grains is generally higher than the silage plant materials used (Salantur, 2003). Özdüven and Ögün (2006), who ensiled the sunflower product using 25% and 50% wet beer pulp (barley pulp) without additives, noted that the additive application significantly increased the crude protein ratio. Indeed, in our study, the crude protein ratio increased due to the addition of barley. Crude protein ratios of silages with and without additives in different genotypes varied. This was due to the fact that additive application significantly increased the crude protein ratio in some plants and not in others. Similarly, Dumlu (2007) found plant x additive interaction to be very important in forage crops of legume and herbal grass (Figure 4).

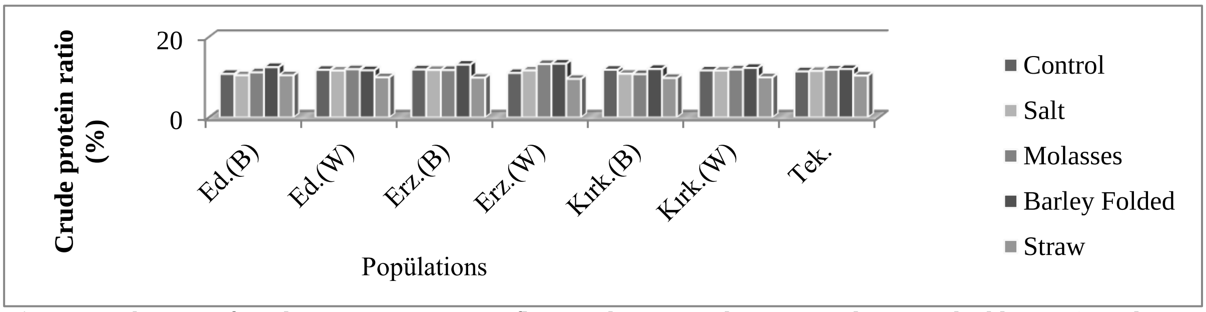

Figure 4. Changes of crude protein ratio in sunflower silage according to population and additives (population x additive interaction)

In all populations, the crude protein ratio decreased as harvest time progressed. This decrease is evident in some populations (such as Tekirdağ population), while in some populations, this ratio is low (Edirne-black -seeded) (Figure 5).

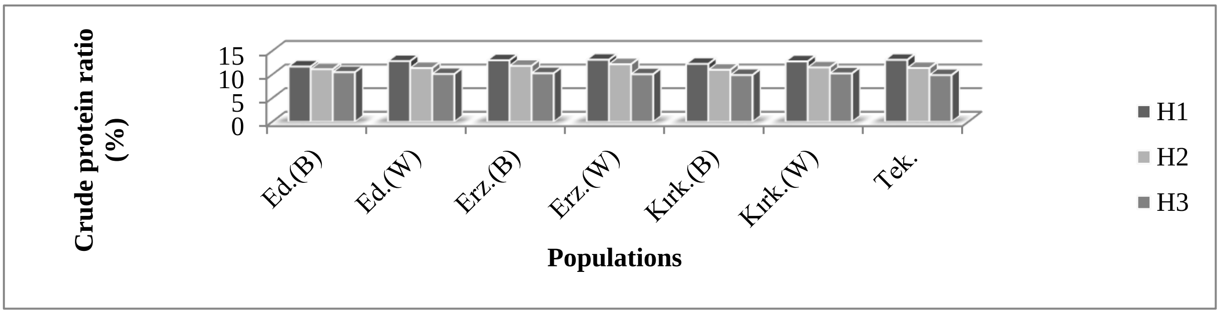

Figure 5. Change of crude protein ratio in sunflower silage according to populations and harvest time (population x harvest time interaction)

Silage pH

It is important to lower the pH for the silage to be successful. In general, it is desired to have a pH below 4.2 in such silages (Dumlu and Tan, 2009). Silage pH values of populations were found between 4.50 and 4.55 with a minor change (Table 2). The main source of the pH in the silo is lactic acid formed during the fermentation. Since this acid has a good protective effect, it gains silage feed a feature that can be stored for a long time (Comberg, 1974; Woolfort, 1984). pH values in this study tended to fall slightly as the harvest time progressed. As a matter of fact, it was recorded that the pH value was 4.66 in the table formation (H1) period, 4.48 in the flowering period (H2) and 4.44 in the seed filling period. The pH values of the last two periods are statistically lower than those of the first period. Tan et al. (2012) reported that pH value decreased in amaranth and lamb's quarters silages with the progress of harvest time, whereas Dumlu et al. (2014) noted that pH value decreased in alfalfa silage. In this study, the pH of the silages without additives was found to be the highest with 4.74, while all the additives decreased the pH value to the same extent (4.44 – 4.53). The fact that the dry matter is high in the silage material facilitates the lowering of the pH. Straw is the most practical and inexpensive additive used to increase dry matter. As a matter of fact, improvement was achieved in this regard with the application of additives and the pH value decreased in the silage with additive (Table 2). There are various reports in the literature about the effect of adding molasses to the silage on pH. Lattemae et al. (1996) stated that the pH of the silage they prepared by adding 4% and 10% molasses to the white triangle is similar to the pure silage pH, while Dolezal et al. (2005) reported that molasses, which they added to lupine silage at the rate of 0.5, 1, 2, 3, 4, 5 and 7, significantly reduced the pH value of the silage. Dumlu (2007) reported that barley folded (5%) and salt (1%) additives have a lowering effect on the legume and grasses silage. Seydosoglu (2019a) reported that barley silage pH 4.11, Seydosoglu (2019b) reported that barley silage 4.08, Seydosoglu and Gelir (2019) reported that grasspea silage pH 3.99, Turan and Seydosoglu (2020) reported that Italian Ryegrass silage pH 4.40, Karadeniz et al. (2020) reported that triticale silage 3.95. In all of the additives used in this study, the highest pH value was observed in table-formation period which was the first harvest period. While the pH value decreased with the progress of the harvest time in the silage without additive (control) and barley-added silage, it increased in salt and molasses-added silage (Figure 6). In straw-containing silage, the pH values in the flowering (H2) and seed filling periods (H3) were equal. The change in pH values of additives in harvest times caused the contribution x harvest time interaction to be statistically significant ($p < 0.01$) (Figure 6).

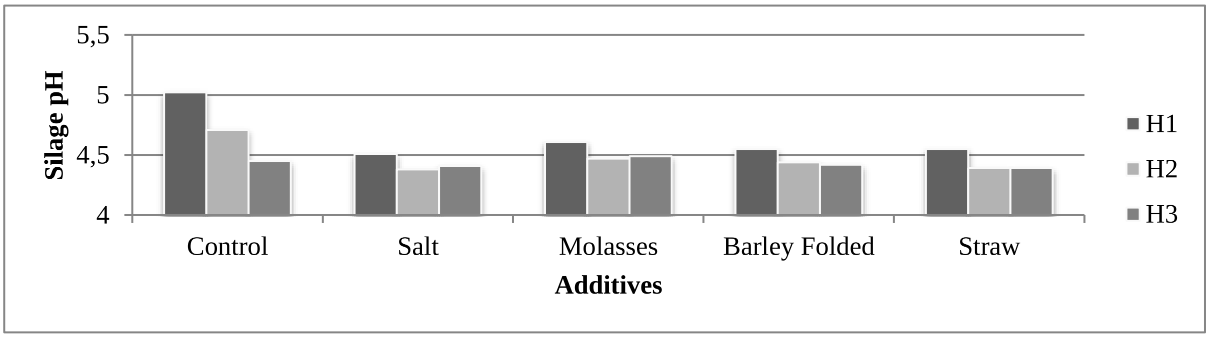

Figure 6. Change of pH value in sunflower silage according to additive and harvest time (additive x harvest time interaction)

NDF (Neutral Detergent Fiber) ratio

The overall average of NDF rate desired to be low in terms of silage quality is 58.94% in our study. The lowest NDF ratios were found in Kırklareli-black (58.47%) and Edirne-black (58.50%) populations, and the highest value (59.44%) was found in the Tekirdağ population. This statistically significant difference among populations is due to the difference in the proportion of fiber that each population has. Similarly, Güney et al. (2012) determined NDF rates of different sunflower populations at different rates.

Table 3. NDF, ADF, RFV ratios of sunflower populations that are harvested at different developmental stages and ensiled with different additives [1]

Population	NDF (%)	ADF (%)	RFV
Edirne (black seed)	58.50 D	34.56 AB	100 A
Edirne (white seed)	5928 AB	34.32 B	98 C
Erzurum (black seed)	58.81 CD	33.93 C	100 A
Erzurum (white seed)	58.82 CD	34.85 A	98 C
Kirklareli (black seed)	58.47 D	34.69 AB	99 B
Kırklareli (white seed)	58.94 B	34.64 AB	99 B
Tekirdag	59.44 A	34.80 A	98 C
Harvest Time			
Table Formation(H1)	55.74 C	31.00 C	109 A
Full Flowering (H2)	58.76 B	34.07 B	99 B
Seed Filling (H3)	62.21 A	38.59 A	88 C
Additives			
Control	59.24 B	34.95 B	97 D
Salt	57.28 C	33.61 C	102 C
Molasses	56.63 D	33.51 C	104 B
Barley Folded	56.32 D	32.86 D	105 A
Straw	65.00 A	37.79 A	85 E
Average	58.94	33.54	99
F-test (LSD value)			
Population	** (0.40)	** (0.36)	** (0.82)
Additives	** (0.34)	** (0.31)	** (0.69)
Harvest Time	** (0.22)	** (0.23)	** (0.54)
PXA	** (0.89)	** (0.81)	** (1.84)
PXHT	** (0.69)	** (0.63)	** (1.42)
AXHT	** (0.44)	** (0.53)	** (1.20)
PXAXHT	** (1.56)	** (1.41)	** (3.18)

[1]Averages marked with capital letters are different at 1% level. * It shows significance at 0.05 level, **: 0.01 level.

In general, as the vegetation period progresses in most plants, the leaf stem ratio decreases, on the other hand, the raw cellulose and lignin content gradually increases (Albrecth et al., 1987). As a result, ADF and NDF ratios increase. Consequently, in our study, the NDF ratio increased as the harvest period was delayed (Table 3). The NDF ratio, which was 55.74% in the table formation (H1) period, increased to 58.76% in the flowering period (H2). In the seed filling (H3) which is the last period, it was recorded as 62.21%. Ripening increases cell wall substances in plants, and thereby ADF and NDF ratios (Fahey, 1994). In addition, the increase in the rate of stems compared to leaf in plants causes an increase in structural compounds (Nelson and Moser, 1994). Likewise, Tan et al. (2012) examined the amaranth and lamb's quarters silage at the beginning and end of flowering and reported that NDF ratio increased with maturation. The effect of additives used in silo on NDF ratio is important in statistical sense ($p<0.01$) (Table 3). The average NDF ratio of silage without additives (control) was found to be 59.24%. All of the additives applied had a decreasing effect on NDF except for straw. It is expected to increase the NDF ratio due to the fact that straw contains a large amount of substances that limit feed consumption and digestion (Şehu et al., 1996). It is known that molasses improves fermentation and accordingly decreases ADF, NDF ratios (Bolsen et al., 1996). Since barley has a structure that facilitates digestion depending on the height of its cellulose content, it had an effect on reducing ADF and NDF ratios. Similar results were obtained in relevant studies (Tan et al., 2012; Can et al., 2003; Can et al., 2004). In silages made from sunflower populations, straw additives had an increasing effect on NDF, while barley additives had an decreasing effect on NDF. Salt and molasses additives vary between populations in terms of NDF ratio. In some populations, molasses-added silages had higher NDF ratio, whereas in some populations, salt was replaced by molasses (Figure 7).

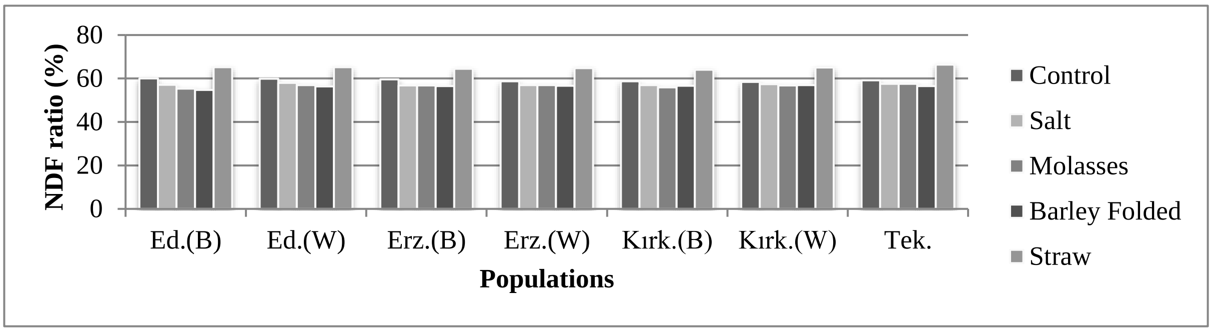

Figure 7. Variation of NDF ratio according to population and additives in sunflower silage (population x additive interaction).

It is known that digestion becomes difficult as plant matures. Therefore, NDF ratios, which are the digestibility criteria in all additive and additive silage, increased with the progress of harvest time. Silages with barley additives are the ones with the least increase. Barley additives were followed bymolasses, salt and silages without additive (control). The biggest increase in NDF is seen in silage with straw additives as in ADF. The additives, especially the barley additive, were beneficial in reducing the disadvantages caused by the delayed harvest time (Figure 8).

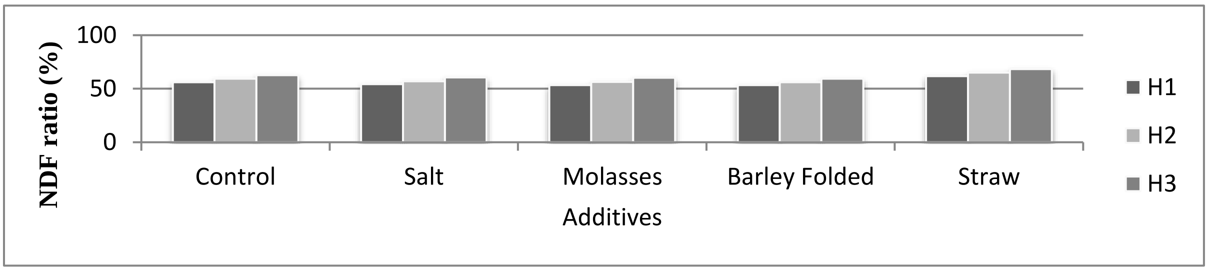

Figure 8. Change of NDF ratio according to additive and harvest time in sunflower silage (additive x harvest time interaction).

The NDF ratio increased in all populations discussed in the experiment with the progress of harvest time (Table 3). This increase occurred at different rates among the populations. In other words, although the populations and harvest times were the same, the increase rates were different (Figure 9).

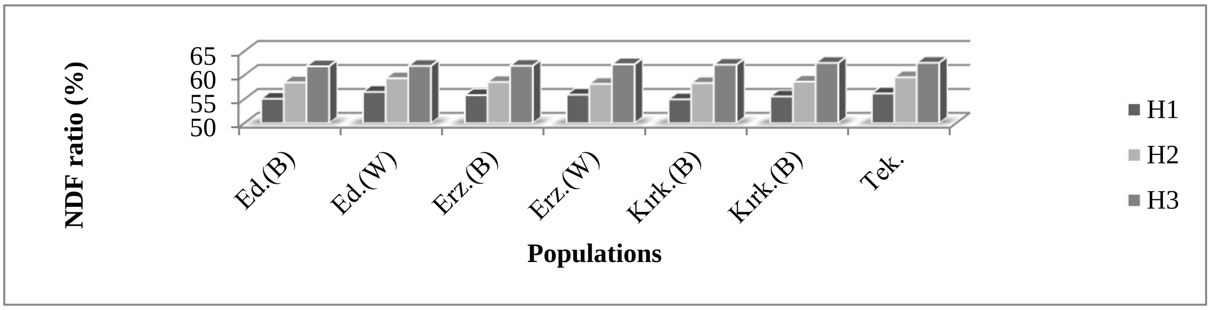

Figure 9. Variation of NDF ratio according to population and harvest time in sunflower silage (population x harvest time interaction).

The reaction of sunflower populations used in the study to harvest time and additive applications were different in terms of NDF. The NDF ratio, which was low in the table forming (H1) period in all populations, increased during the flowering (H2) and seed forming (H3) periods. Among the additives applied, straw was the additive with the highest NDF rate for all populations. Straw were followed by silages without additive (control).

ADF (Acid Detergent Fiber) ratio

The average ADF value of all materials discussed in the experiment is 33.54% (Table 3). The average of population silage varied between 33.93% and 34.85%. Acid detergent fiber ratio (ADF) is an indicator of digestibility of roughages and it is desired to be low. Among the silages examined, the silage material with the lowest ADF ratio (33.93%) is the black-seeded Erzurum population. The highest values were determined in Tekirdağ (34.80%) and Erzurum (34.85%) populations with white seeds. The difference of the populations with the highest valuesfrom Erzurum-black and Edirne-white populations is statistically significant (Table 3). The leaf, stem and tray ratios of each population may differ from each other, and their ADF ratios may differ as well. Similarly, Güney et al. (2012) found that ADF rates of four sunflower genotypes ranged from 32.11% to 35.02%.

It is seen in Table 3 that the ADF rate increased depending on the progress of harvest process. The ratio of ADF, which was 31.00% during the table formation (H1) period, increased to 34.07% during the flowering period (H2). In seed filling period which is the last period (H3), it was recorded as 38.59%. Ripening increases cell wall substances in plants, thus ADF and NDF ratios (Fahey, 1994). In addition, the increase in the rate of stems in plants causes an increase in structural compounds (Nelson and Moser, 1994). These situations caused ADF and NDF ratios to increase with the progress of harvest time. The effect of additives used during ensiling on ADF ratio is important in statistical sense ($p < 0.01$) (Table 3). The mean ADF ratio of silage without additives (control) was determined as 34.95%. All of the additives applied had a decreasing effect on the ADF rate, except for straw. The abundance of structural materials that make digestion difficult in straw, which is a mature vegetable material, caused this. Similarly, Yalçınkaya et al. (2012) reported that 0,1% urea and straw additive to apple, peach and apricot pulp silage increased the ADF ratio. Molasses and salt additives reduced the ADF content of the silage (33.51% and 33.61%, respectively). In similar studies, molasses and salt showed the same effect (Bolsen et al., 1996; Keskin et al., 2005; Bingöl et al., 2010). Roughages are generally structures with a high content of raw fiber (such as ADF and NDF). Although barley is used as an additive, it consists of grains to a large extent. Since the fiber rate of barley grain is very low compared to the roughages, it is natural to decrease the ADF and NDF ratios of silages with the addition of grain breakage. That is why, Tan et al. (2012) and Can et al. (2003) found that salt and barley folded decreased ADF rate. Straw additives significantly increased the ADF rate in all populations discussed in the experiment. Silages without additives (control) are the ones with the highest ADF ratio after silage with straw additives (Figure 10). On the other hand, barley-added silages are the ones with the lowest ADF rate for each population. Salt and molasses additives vary between populations in terms of ADF ratio.

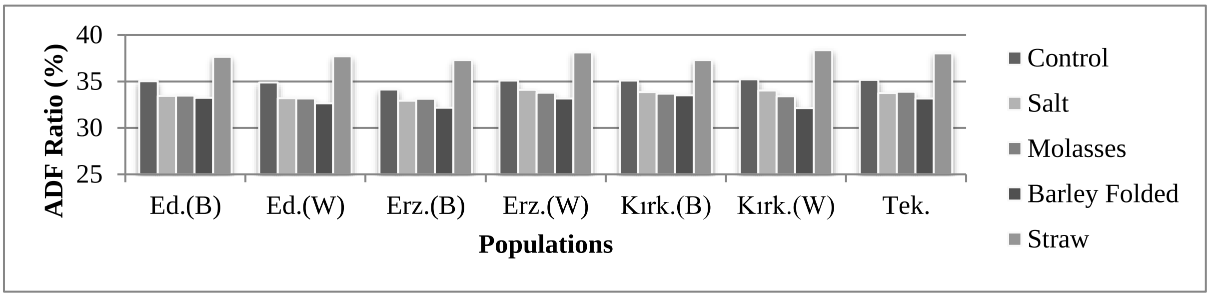

Figure 10. Change of ADF rate according to population and additives in sunflower silage (population x additive interaction)

Acid insoluble fiber ratio (ADF) in all silages with and without additives increased with the progress of harvest time. While the increase in the ADF rate was less in barley-containing silage, the ADF rate in the straw additives silages had a more significant increase. Following the maturation of the plant, the fact that the additives increased the ADF rate differently led to a statistically significant contribution x harvest time interaction (Figure 11).

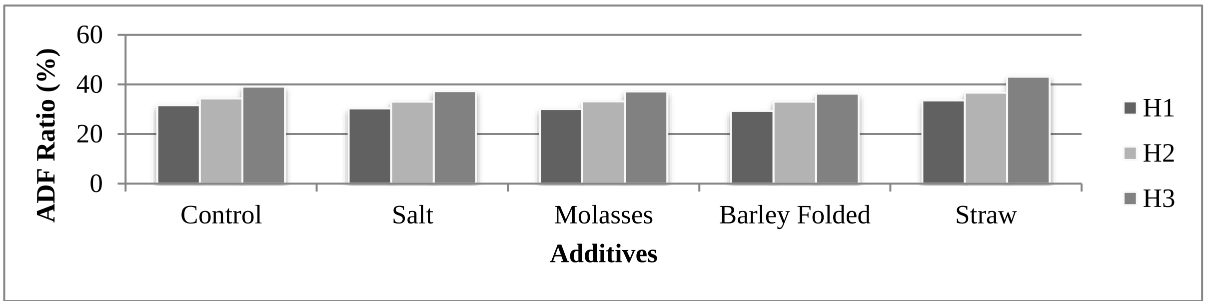

Figure 11. Change of ADF ratio in additives and harvest times in sunflower silage (additive x harvest time interaction)

In all populations discussed in this experiment, the ADF ratio increased with the progress of harvest time (Table 3). This increase occurred at different rates among the populations. In other words, although the populations and harvesttimes were the same, the rates of increase were different (Figure 12).

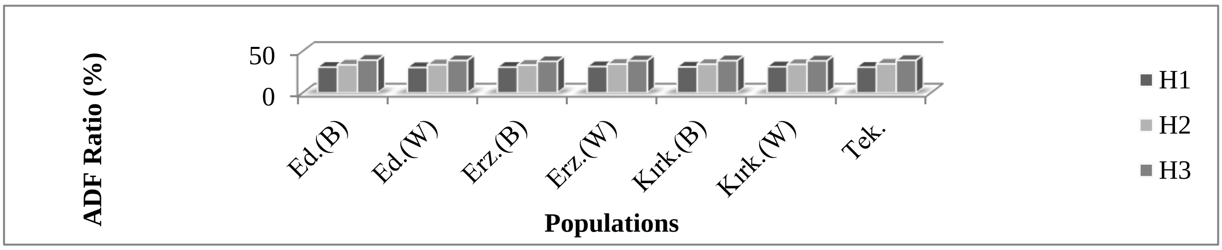

Figure 12. Variation of ADF rate according to population and harvest time in sunflower silage (population x harvest time interaction)

Harvest time applications discussed in the experiment caused a significant difference in ADF ratios. In all populations, the ratio of ADF, which was low during the table forming (H1) period, increased during the flowering (H2) and seed forming (H3) periods. Especially the increase in the transition from H2 to H3 was more apparent. Among the additives applied, straw is the additive with the highest ADF ratio for all populations. Silages without additive (control) were followed by straw. The fact that the populations reacted differently to additives and harvest times caused the contribution x population x harvest time interaction to be statistically significant.

Relative feed value (RFV)

As a two-year average of herbal materials which were investigated in this experiment, the ratio of RFV is 99% (Table 3). The populations with the highest relative feed value are Edirne (black seeded) (100%) and Erzurum (black seeded) (100%) populations, followed by Kırklareli populations (99%). Tekirdağ, Edirne (white seeded) and Erzurum (white seeded) populations had the lowest relative feed value with 98%. Statistically significant differences were foundamong these groups. The relative feed value is a combination of ADF and NDF ratios in the herb, and it is an expected result that the relative feed values of the populations with these two different characteristics are different as well. Similarly, Canbolat and Karaman (2009) reported that the relative forage values of legume dried herbs varied between 120 and 160. The relative feed value decreased in plants due to the progress of harvest time (Table 3). The relative feed value ratio, which was 109% in the table formation (H1) period, was 99% in the flowering period (H2) and 88% in the seed filling (H3) period. Depending on the maturation of the plant, the increase in the cell wall components (such as ADF and NDF) that make the digestion of the feed difficult affected the relative feed value negatively. This situation had a statistically significant effect on the relative feed value of the harvest time ($p<0.01$). Similar results were obtained in the studies (Canbolat, 2013; Dumlu et al., 2014; Schröeder, 2004). The effect of additives used during ensiling on the relative feed value ratio is statisticallysignificant ($p<0.01$) (Table 3). The average ratio of relative feed value of the silage without additives (control) was determined as 97. The highest relative feed rate was observed in silage with barley additives (105), followed by molasses (104) and salt (102) additives. All of the additives used in this study had an effect on increasing the relative feed rate except for straw, whichstems from the decrease in ADF and NDF ratios because of the additives. Since straw has a structure that limits feed consumption and digestion, it is expected to decrease the relative feed ratio (Şehu et al., 1996). As a matter of fact, in the study carried out by Yavuz (2005), the relative feed value of wheat straw was found 49% and it was described as low quality feed (Yavuz, 2005). Straw additives significantly reduced the ratio of RFV in all populations discussed in the experiment. Silages without additives (control) are those with the lowest RFV ratio followingsilages with straw additives (Figure 13). On the other hand, barley-added silagesarethose with the highest RFV ratio, except for the Kırklareli (black seeded) population. Salt and molasses additives vary among populations in terms of RFV ratio. In some populations, molasses-added silage has a higher RFV ratio, while molasses is replaced by salt in some other populations.

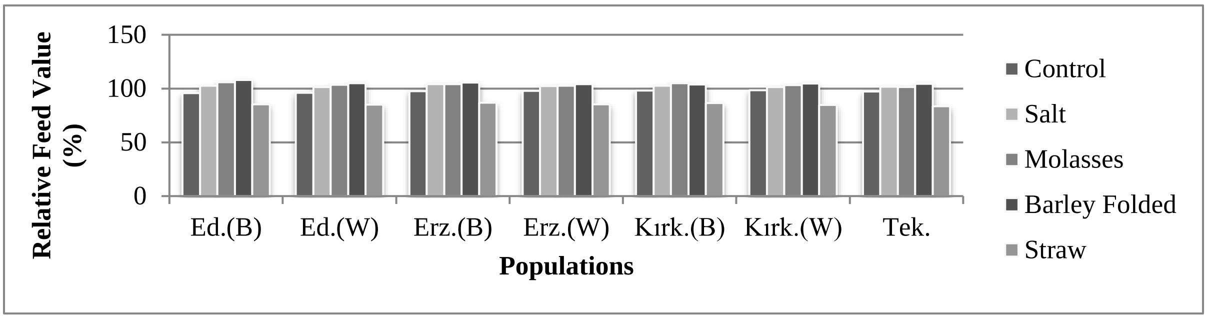

Figure 13. Change of relative feed value in sunflower silage according to additives and populations (additive x population interaction).

It is known that cell wall elements increase and intracellular elements decrease depending on the progression of the vegetation period (Elmalı and Kaya, 2012). This situation makes the relative feed value decrease although it is expected to be high in terms of nutritional quality. As a result, RFV ratios decreased in all of the silages with and without additives depending on the progress of harvest time. Silages with barley additives are the ones with the lowest decrease, followedby molasses, salt and silage without additives (control). The biggest RFV decrease is seen in silage with straw additives as in ADF and NDF (Figure 14). While straw does not improve the relative feed value, other additives, especially barley, have reduced the disadvantages brought about by the maturation of plants.

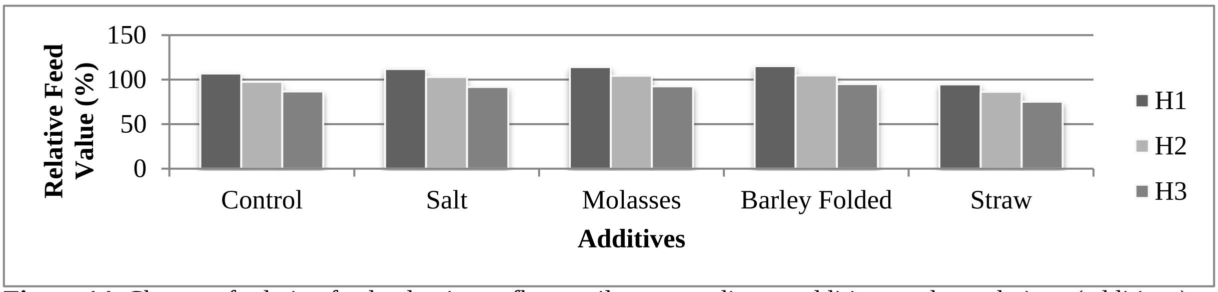

Figure 14. Change of relative feed value in sunflower silage according to additives and populations (additives)

The ratio of RFV decreased in all populations discussed in the experiment with the progress of harvest time (Table 3). This decrease occurred at different rates among the populations. In other words, although the populations and harvest times were the same, the ratios of decline was different. (Figure 15).

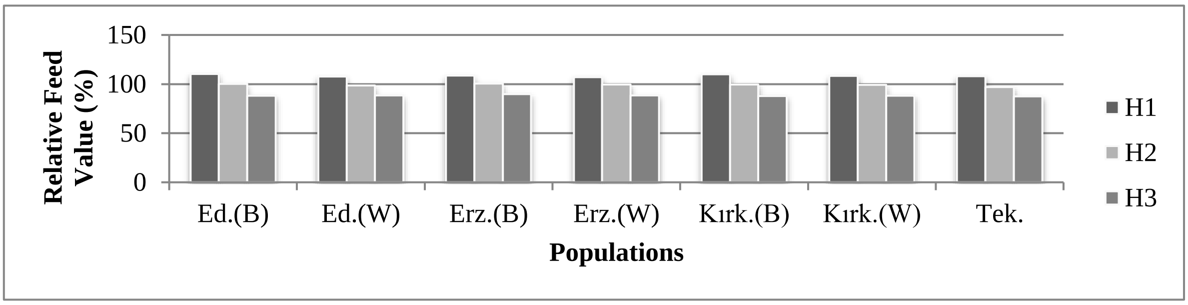

Figure 15. Change of relative feed value in sunflower silage according to populations and harvest time (population x harvest time interaction)

The response of sunflower populations used in the study to harvest time and additive applications were different in terms of RFV. The ratio of RFV, which was high in the table forming (H1) period in all populations, decreased in the flowering (H2) and seed forming (H3) periods. Among the additives applied, straw is the additive with the lowest RFV ratio for all populations, followed by silages without additive (control). The fact that the populations reacted differently to the additives and harvest time caused the contribution x population x harvest time interaction to be statistically significant.

CONCLUSION

This study revealed that good quality silage is obtained when appropriate additives are used in most populations. The use of additives, especially barley and molasses, improves silage quality. Although the delayed harvest time decreased the crude protein ratio and increased the ADF and NDF ratios, it affected the dry matter ratio and silage pH positively. According to the results obtained, Erzurum-black, Edirne-white seeded, Kırklareli-white seeded and Tekirdağ populations can be recommended in terms of silage quality if they are mowed during the grain filling period with additives such as barley and molasses. However, a further study on different additives (such as bacterial inoculants, enzymes, nitrogenous compounds) and their combinations can be conducted to obtain better quality silages.

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