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Effect of Almond (*Prunus dulcis*) Hull Addition to Alfalfa Silage on Silage Quality and *In Vitro* Digestibility

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Abstract: In this study, it was aimed to determine the effects of the addition of almond hull, which has no economic value and causes environmental pollution, to alfalfa silage as an easily soluble carbohydrate source on silage quality, fermentation characteristics and *in vitro* organic matter digestion (IVOMD). The groups were designed to contain 0% (control), 1%, 2%, 4% and 6% almond hull, respectively. When the IVOMD and metabolizable energy (ME) values of the silages were examined, increases were observed in all additive groups compared to the control group. When the pH, NH_3-N/TN and carbon dioxide (CO_2) values of the silages were examined, the highest values were determined in the control group, while the lowest pH, NH_3-N/TN and CO_2 values were determined in the silage group with 6% almond hull added. Although an increase was determined in all trial groups in terms of lactic acid (LA) and acetic acid (AA) values of silages compared to the control group, the highest values were determined in the group with 6% almond hull addition, and a decrease was determined due to the increase in almond hull in terms of butyric acid (BA) values. Yeast and mold values of the silages decreased due to the increase in almond hull compared to the control group. As a result, it was determined that the addition of 6% almond hull as an easily soluble carbohydrate source had a positive effect on alfalfa silage quality and fermentation characteristics.
Keywords: Almond hull, silage, silage additives, silage fermentation

Yonca Silajına Badem (*Prunus dulcis*) Kabuğu İlavesinin Silaj Kalitesi ve *İn Vitro* Sindirilebilirlik Üzerine Etkisi

Öz: Bu çalışmada ekonomik değeri bulunmayan ve çevre kirliliğine neden olan badem kabuklarının kolay çözünebilir karbonhidrat kaynağı olarak yonca silajına ilavesinin silaj kalitesi, fermantasyon özellikleri ve *in vitro*organik madde sindirimi üzerine etkilerinin belirlenmesi amaçlanmıştır. Gruplar sırasıyla %0 (kontrol), %1, %2, %4 ve %6 badem kabuğu içerecek şekilde tasarlanmıştır. Silajların *in vitro* organik madde sindirimi (IVOMS) ve metabolik enerji (ME) değerleri incelendiğinde kontrol grubuna kıyasla tüm katkılı gruplarda artışlar gözlemlenmiştir. Silajların pH, amonyak azotu (NH_3-N/TN) ve karbondioksit (CO_2) değerleri incelendiğinde, en yüksek değerler kontrol grubunda tespit edilirken, en düşük %6 badem kabuğu ilave edilen silaj grubunda tespit edilmiştir. Silajların laktik asit (LA) ve asetik asit (AA) değerleri kontrol grubuna kıyasla tüm deneme gruplarında artış göstermiş, en yüksek %6 badem kabuğu ilavesinin olduğu grupta belirlenmiştir. Bütirik asit (BA) değerleri bakımından badem kabuğu artışına bağlı olarak azalma tespit edilmiştir. Silajların maya ve küf değerleri kontrol grubuna kıyasla badem kabuğu artışına bağlı olarak azalmıştır. Sonuç olarak kolay eriyebilir karbonhidrat kaynağı olarak %6 badem kabuğu ilavesinin yonca silaj kalitesi ve fermantasyon özellikleri üzerine olumlu etkisinin olduğu belirlenmiştir.
Anahtar kelimeler: Badem kabuğu, silaj, silaj katkıları, silaj fermantasyonu

Introduction

Alfalfa is a perennial and multiform plant among leguminous forage crops, and it is a delicious forage plant rich in nutrients, especially crude protein (Gökkaya and Orak, 2021). Additives are needed in case of silage making, because the alfalfa plant is insufficient in terms of easily soluble carbohydrates and its buffering capacity is high (Kurtoğlu, 2011). In order to eliminate these negativities, the use of easily soluble carbohydrate sources such as molasses, whey and cereal grains to alfalfa silage has found a widespread application area (Topçuoğlu and Ersan 2020). Almond, one of the easily soluble carbohydrate sources, is a stone fruit seed belonging to the

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"Amygdalus" genus of the "Prunoideae" subfamily of the "Rosaceae" family of the "Rosales" team. Almond cultivation is carried out in Turkey, mostly in the Aegean Region (especially the Datça peninsula), and in the Mediterranean, Central Anatolia and Marmara Regions. As a result of breeding studies carried out in recent years, the emergence of new varieties with high efficiency and high economic return increases the interest in almond cultivation. For this reason, it is observed that almond production is increasing rapidly in Southeastern Anatolia and other regions. Almonds contain approximately 50% fat, 16.9% starch and 100 g has an energy content of approximately 575 kcal. Almonds contain high levels of monounsaturated fatty acids (MUFA) (62%) and are known to have the lowest saturated fat content (24%) among all nuts (Topçuoğlu and Ersan, 2020). The yield part of almond consists of 23% hazelnut kernel, 13% waste material, 14% shell and 50% hull. Almond hulls contain 10-30% moisture, 10-17% fiber, 1-4% oil, 2-5% protein and 50-60% nitrogen-free extract. This nitrogen-free extract contains sugars and other carbohydrates (EPA 1995; Holtman and ark., 2015).

This study was carried out to determine whether the addition of almond hull, which has no economic value and causes environmental pollution, to alfalfa silage as an easily soluble carbohydrate source has a positive effect on silage quality, fermentation properties and *in vitro* organic matter digestion.

Material and Method

The silage material of the research consisted of alfalfa grown in a farm in Şanlıurfa. The alfalfa (*Medicago sativa* L) used in the study was harvested at full bloom and chopped in a silage machine in sizes of 1.5-2.0 cm. Almond hulls (AH) were taken as dried and ground from an almond processing plant in Şanlıurfa organized industrial zone. The buffering capacity of the fresh alfalfa used in the study was determined according to the method reported by Playne and McDonald (1966). In the study, while alfalfa plant without additives constituted the control group, the trial groups consisted of 1%, 2%, 4% and 6% almond hulls added groups. Control and each trial group were compressed into 1.5-liter glass jars in 4 repetitions. The silages were fermented in a dark environment for 60 days before opening. During this time, the silages were stored at room temperature. After the silages were opened, a 3-5 cm section was discarded from the top of the jar. After the silages were poured into a container, approximately 25 g of silage sample was mixed homogeneously with 100 ml of distilled water with the help of a blender. The macerated silage samples were filtered through two layers of cheesecloth and the pH values of the filtrate were measured with a laboratory pH meter (Hanna instruments, Romania (WTW-7310)) (Polan et al.,1998). 10 ml samples were taken from the obtained silage liquid in blender and placed in tubes after filtering. In addition to the silage liquid, 0.1 ml of 1 M HCl was added to the tubes prepared for ammonia nitrogen (NH_3-N) analysis. For the analysis of lactic acid and volatile fatty acids, 0.25 ml of 25% metaphosphoric acid was added to the prepared tubes.The tubes prepared for ammonia nitrogen, lactic acid and volatile fatty acids analyzes were stored in the deep freezer until analysis. NH_3-N/TN analyzes of the silage samples were performed according to the method reported by Broderick and Kang (1980). Volatile fatty acids such as propionic acid, acetic acid and butyric acid and lactic acid were determined as reported by Suzuki and Lund (1980). For this reason, high performance liquid chromatography (HPLC) device (Shimadzu LC-20 AD HPLC pump, Icsep-Coregel (87H3 colon), Shimadzu SIL-20 ADHT Autosampler, Shimadzu cto-20ac Colum oven, Shimadzu SPD M20A Detector (DAD), Japan) was used. The silages obtained in the study were subjected to aerobic stability test in order to determine the CO_2 production values. For this purpose, silages were developed by Ashbell et al. (1991) was exposed to oxygen for 5 days according to the method reported.

While the raw nutrient contents of the silages (such as dry matter, crude ash, crude protein) were made according to the method reported by AOAC (2005), the acid detergent fiber (ADF) and neutral detergent fiber (NDF) analyzes of the silages were performed as reported by Van Soest et al. (1991). Before the raw nutrient analysis, the silages were dried at room temperature and ground in a laboratory mill to pass through a 1 mm sieve and made ready for analysis. While determining the *in vitro* organic matter digestibility (IVOMD), metabolizable energy (ME) and *in vitro* methane (CH_4) contents of silages, the method reported by Menke and Steingass (1988) was applied.The gas production values of the silages were determined through the method described by Menke and Steingass (1988) using four glass syringes as replicate. The *in vitro* organic matter digestibility (IVOMD) (g/kg OM) and metabolizable energy (ME) (MJ/kg DM) of silages were calculated using equations reported by Menke and Steingass (1988).

$$ME(MJ/kgDM) =2.20+0.136\times Gp+0.057\times CP+0.0029\times CP^2,$$

$$IVOMD (\%)=14.88+0.889\times Gp+0.45\times CP+0.0651\times XA,$$

where CP is CP in g/100 g DM, crude ash in g/100 g DM and gas production is the net gas production (ml) from 200 mg DM after 24 h of incubation. After recording 24-h gas production values, gas inside the syringe was taken by three-way syringe system and total gas was injected into computer-assisted infrared methane gas meter (Sensor Europe GmbH, Erkrath, Germany) and then methane content was determined as a percentage of 24 h the total amount of gas formed (Goel et al.2008) Yeast and mold contents of silages were determined using the method reported by Filya et al. (2000).The conformity of the data to the normality distribution was determined by looking at the Histogram graph. One Way Analysis of Variance (One Way ANOVA) was used in the evaluation of the data obtained as a result of the research. The homogeneity of the variances was examined in the Test of Homogeneity of Variance analysis. Duncan's multiple comparison tests were applied to compare group means by using SPSS (1991) package program. A value of 0.05 was used as the level of significance between the groups.

Results

The nutrient analysis results of alfalfa plant used as silage material and almond hull used as additive in the study are presented in Table 1. When Table 1 was analyzed, DM, CA, CP, ADF, NDF, IVOMD, ME and CH_4 values of alfalfa plant used as silage material are 23.45%, 13.05 DM%, 16.70 DM%, 34.99% DM%, 56.44% DM%, 58.52%, 8.79 MJ, respectively. For the same parameters /kg DM and 14.68%, almond hulls values were determined as 92.50%, 15.50 DM%, 3.80 DM%, 35.59% DM%, 50.76% DM%, 34.39%, 4.98 MJ/kg DM and 1.30%, respectively.

The nutrient contents, IVOMD, ME and *in vitro* CH_4 values of the silages prepared by adding almond hull at different rates (1%, 2%, 4% and 6%) to alfalfa plants are given in Table 2. When Table 2 was analyzed, it was found that the differences between the groups were statistically significant in DM, CA, CP, ADF and NDF, IVOMD, ME values of the silages (P<0.05).

Within the scope of this study, the fermentation characteristics of the silages prepared by adding different ratios of almond hull to alfalfa plant as an easily soluble carbohydrate source and the correlation results of the analyses are given in Table 3 and Table 4. When Table 3 was analyzed, it was seen that the differences between the groups were significant when the fermentation characteristics (pH, NH_3-N, LA, AA, yeast, mold, CO_2) of the silages were examined (P<0.05). When Table 4 is examined, it has been determined that there is a correlation between the fermentation characteristics of alfalfa silages and the yeast and mold values.

Table 1. Crude nutrient contents of alfalfa plant used as silage material and almond hull used as additive in the study

	BC	DM	CA	CP	ADF	NDF	IVOMD	ME	CH_4
Alfalfa	450	23.45	13.05	16.70	34.99	56.44	58.52	8.79	14.68
Almond hull	-	92.50	15.50	3.80	35.59	50.76	34.39	4.98	1.30

***BC**: Buffering capacity meq/kg DM, **DM:** Dry matter, %; **CA:** Crude ash DM%; **CP:** Crude protein, DM%; **ADF:** Acid detergent fiber, %DM; **NDF:** Neutral detergent fiber, %DM; **IVOMD:**In vitro organic matter digestibility %, **ME:**Metabolizable energyMJ/kg DM, **CH_4:** In vitro methane gas (%).*

Table 2. Nutrient contents and IVOMD, ME and *in vitro* CH_4 values of alfalfa silages prepared by adding almond hull at different rates

Groups	DM±SE	CA±SE	CP±SE	ADF±SE	NDF±SE	IVOMD±SE	ME±SE	CH_4±SE
Control	20.49^{c}±0.23	12.93^{a}±0.14	16.27^{a}±0.04	34.85^{b}±0.67	49.61^{b}±0.27	53.29^{b}±0.50	7.84^{b}±0.07	14.60±0.21
%1 almond hull	20.52^{c}±0.73	12.43^{a}±0.29	16.75^{a}±0.26	35.48^{b}±0.28	50.12^{b}±0.34	53.52^{b}±0.62	7.87^{b}±0.11	13.28±1.17
%2 almond hull	21.41^{c}±0.27	11.42^{b}±0.15	16.82^{a}±0.14	35.99^{ab}±0.40	50.16^{b}±0.64	57.43^{a}±1.27	8.69^{a}±0.07	14.64±0.13
%4 almond hull	23.04^{b}±0.63	11.16^{b}±0.09	15.46^{b}±0.23	36.04^{ab}±0.28	52.66^{ab}±0.97	57.86^{a}±1.46	8.54^{a}±0.28	15.24±0.17
%6 almond hull	25.02^{a}±0.63	11.06^{b}±0.06	15.34^{b}±0.17	37.13^{a}±0.43	54.31^{a}±1.81	58.80^{a}±0.26	8.60^{a}±0.92	14.89±0.31
P	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	>0.05

*$^{a-c}$**:** Values with different letters in the same column were found to be different (P<0.05); **SE:**Standard error,**DM:**Dry matter, %; **CA:** Crude ash DM%; **CP:** Crude protein, DM%; **ADF:** Acid detergent fiber, %DM; **NDF:** Neutral detergent fiber, %DM; **IVOMD:**In vitro organic matter digestion %, **ME:**Metabolizable energy MJ/kg DM ,**CH_4:**In vitro methane gas (%).*

Table 3. Fermentation characteristics of alfalfa silages prepared by adding almond hulls at different rates

Groups	pH±SE	NH_3N/TN±SE	LA±SE	AA±SE	PA±SE	BA±SE	YEAST±SE	MOLD±SE	CO_2±SE
Control	5.55^{a}±0.01	33.68^{a}±1.45	4.58^{e}±0.03	6.84^{d}±0.02	0.76^{b}±0.01	9.42^{a}±0.01	3.09^{a}±0.01	5.61^{a}±0.01	2.38^{a}±0.01
%1 almond hull	5.48^{a}±0.03	19.81^{b}±0.73	6.07^{d}±0.07	7.37^{c}±0.01	0.43^{c}±0.01	6.64^{b}±0.02	1.01^{b}±0.00	3.46^{b}±0.01	1.78^{ab}±0.01
%2 almond hull	5.56^{a}±0.18	17.11^{bc}±1.09	8.67^{c}±0.03	7.42^{c}±0.02	1.19^{a}±0.01	6.44^{c}±0.01	0.00^{c}±0.00	3.29^{c}±0.01	1.34^{b}±0.01
%4 almond hull	4.60^{b}±0.18	14.42^{c}±0.40	14.44^{b}±0.02	9.03^{b}±0.02	0.00^{d}±0.00	5.44^{d}±0.02	0.00^{c}±0.00	3.00^{d}±0.01	1.26^{b}±0.01
%6 almond hull	4.49^{b}±0.11	11.58^{d}±0.64	27.33^{a}±0.04	14.03^{a}±0.05	0.00^{d}±0.00	0.00^{e}±0.00	0.00^{c}±0.00	2.35^{e}±0.02	1.25^{b}±0.01
P	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**	**<0.05**

[a-e:] *Values with different letters in the same column were found to be different ($P<0.05$);* ***SE:****Standarderror,* ***NH_3-N/TN:*** *Ammonia nitrogen,* ***CO_2:*** *Carbon dioxide g/kg DM,* ***LA:*** *Lactic acid g/kg DM,* ***AA:*** *Acetic acid g/kg DM,* ***PA:*** *Probiotic acid;* ***BA:*** *Butyric acid g/kg DM,* ***Yeast:*** *log10/cfu/g,* ***Mold****: log10/cfu/g*

Table 4. Correlation relationship between fermentation characteristics and yeast and mold values of alfalfa silages prepared by adding almond hull at different rates

		NH_3-N/TN	LA	AA	PA	BA	Yeast	Mold	CO_2	IVOMD	ME	CH_4
pH	**PC**	.657**	-.768**	-.790**	.824**	.650**	.527*	.633**	.469*	-.600**	-.447*	-.337
	P	.002	.000	.000	.000	.002	.017	.003	.037	.005	.048	.146
NH_3-N	**PC**	1	-.603**	-.645**	.476*	.756**	.952**	.973**	.733**	-.655**	-.610**	-.090
	P		.005	.002	.034	.000	.000	.000	.000	.002	.004	.706
LA	**PC**		1	.398	-.668**	-.247	-.600**	-.556*	-.508*	.553*	.482*	.378
	P			.082	.001	.294	.005	.011	.022	.011	.031	.100
AA	**PC**			1	-.671**	-.922**	-.506*	-.683**	-.434	.577**	.432	.226
	P				.001	.000	.023	.001	.056	.008	.057	.338
PA	**PC**				1	.580**	.304	.495*	.272	-.280	-.080	-.128
	P					.007	.192	.027	.245	.232	.737	.591
BA	**PC**					1	.631**	.816**	.490*	-.497*	-.380	-.042
	P						.003	.000	.028	.026	.098	.860
Yeast	**PC**						1	.954**	.747**	-.656**	-.671**	-.147
	P							.000	.000	.002	.001	.537
Mold	**PC**							1	.717**	-.619**	-.579**	-.091
	P								.000	.004	.008	.703
CO_2	**PC**								1	-.468*	-.465*	.043
	P									.037	.039	.856
IVOMD	**PC**									1	.908**	.382
	P										.000	.097
ME	**PC**										1	.377
	P											.101
CH_4	**PC**											1

PC: *Pearson correlation.* ****:*** *Correlation is significant at 0.05 level.* *****:*** *Correlation is significant at 0.01 level.* ***NH_3-N/TN:*** *Ammonia nitrogen.* ***CO_2:*** *Carbon dioxide g/kg DM.****LA:*** *Lactic acid g/kg DM.****AA:*** *Acetic acid g/kg DM.****PA:*** *Probiotic acid g/kg DM;* ***BA:*** *Butyric acid g/kg DM.* ***IVOMD:****In vitro organic matter digestion %.****ME:****Metabolizable energy.****CH_4:*** *In vitro methane gas (%).*

Discussion and Conclusion

When Table 2 was analysed, it was found that the differences between the groups were statistically significant in DM, CA, CP, ADF and NDF, IVOMD, ME values of the silages, while the differences between the *in vitro* CH_4 values were not statistically significant.

When the DM contents of the silages prepared by adding different ratios of almond hull to alfalfa plants were analysed, an increase in the DM levels was observed in parallel with the increase in the addition of almond hull compared to the control group. The increase in DM level can depend on the high DM level of almond hull. When the CA values were analysed, a decrease was observed due to the addition of almond hulls. Kurtoğlu (2011) reported that this was due to the difference in inorganic matter levels of silage materials and additives. When the CP values of the silages were examined, a decreasing trend was observed in the CP level depending on the addition of 4% and 6% almond hulls. This decrease was due to the low CP content of almond hulls. When ADF and NDF values of the silages were analysed, an increase in ADF and NDF values was observed parallel to the increase in almond hull. In this study, the difference in ADF and NDF values between the control group and the trial groups was considered to be due to the high ADF and NDF contents of almond hull.

Kepekci (2020) reported that the addition of anise seed as an easily soluble carbohydrate source to alfalfa silage increased NDF values. When IVOMD and ME values of silages were examined, increases were observed in all trial groups compared to the control group. It was considered that the main fermentation product in silages was LA and LA was fermented in the rumen and evaluated by ruminants and accordingly increased IVOMD and ME values (Okuyucu et al., 2018). When Table 4 was examined, it was seen that there was a positive correlation between LA and IVOMD (R: 0.553) and LA and ME (R: 0.482). Similarly, Şakalar and Kamalak (2016) reported that the addition of sugar beet pulp as an additive to alfalfa silage increased IVOMD and ME values, which supports the results obtained from this study.

When the fermentation characteristics (pH, NH_3-N, LA, AA, yeast, mold, CO_2) of alfalfa silages prepared by adding almond hulls at different rates were examined, the differences between the groups were found to be significant ($P<0.05$). When the pH values of the obtained silages were analysed, the highest pH value (5.55) was obtained from the control group, while the lowest pH value (4.49) was determined in the group with 6% almond hull addition. As the water-soluble carbohydrate content of the silage material increases, the ideal acidic environment required for obtaining qualified silage is formed. Therefore, it is expected that the silage pH will decrease with the addition of almond hull to alfalfa silage. In this study, the lower pH values in the almond hull added groups compared to the control group may be attributed to the fact that the low water-soluble carbohydrate content of alfalfa plant was tolerated with almond hull additive and the lactic acid values in the additive groups were high due to the effect of this additive. When the correlation table of the silages obtained was examined, it was observed that there was a negative correlation between pH and LA. Similarly, Stallings et al. (1981) reported that the addition of 1% arabinose and 1% glucose to alfalfa plants decreased pH values in silages and increased silage quality.

When the NH_3-N/TN values of the silages prepared in this study were compared, it was determined that although a decrease was observed due to almond hull addition, the highest NH_3-N/TN value (33.68) was in the control group, while the lowest NH_3-N/TN value (11.58) was in the group with 6% almond hull addition. It was considered thought that this decrease in silage NH_3-N/TN values was due to the fact that easily soluble carbohydrate sources had a positive effect on silage fermentation and reduced proteolysis (Bingöl et al., 2009). Similarly, Yakışır and Aksu (2019) reported that dried sugar beet pulp with molasses, which they added to alfalfa silage at different levels, considerably prevented the denaturing of protein fractions. It was reported that the use of additives with easily soluble carbohydrate content as an additive source in silage production from alfalfa plants created a good fermentation environment for lactic acid bacteria, and microorganisms can multiply rapidly and minimize protein degradation by lowering the pH of the environment (Kung et al., 1984). When the correlation table was examined, the observation of a negative correlation (R:-0.603) between LA and NH_3-N/TN supports this report.

When the LA and AA values of the silages were examined, increases in LA and AA values were observed in all trial groups compared to the control group, but the highest values were determined in the group with 6% almond hull addition. Orloff and Muller (2008) reported that the water-soluble carbohydrate content of high-quality alfalfa silage during the fermentation stage was converted to LA and AA, and the pH of the environment was rapidly reduced to the level of 4-5. When the correlation table was examined, it was seen that there was a positive correlation (R: 0.398) between LA and AA. Gao et al. (2021) reported an increase in LA values due to the addition of molasses and fructose to alfalfa silage, which agreed with the present study. Tabacco et al. (2006) reported that the addition of chestnut shell increased the LA value in alfalfa silage prepared by adding 2, 4 and 6% chestnut tannin compared to the control group. In the silages prepared with the addition of almond hulls at different ratios in this study, PA was not observed in the groups with 4% and 6% almond hull addition, while the highest PA value (1.19 g/kg DM) was determined in the group with 2% almond hull addition ($P<0.05$). The BA values of alfalfa silages prepared in this study showed a decreasing trend due to the increase in almond hulls, but it was not observed in the group with 6% almond hull ($P<0.05$). The fact that alfalfa plant has high CP and low DM and WSC content causes a deficiency in lactic acid production, which is necessary to inhibit the growth of *clostridial* bacteria (Weinberg et al., 1988). As a result of this situation, *saccharolytic clostridia* convert WSC and organic acids in the plant structure into butyric acid (Ohshima et al., 1997). Although butyric acid is an undesirable organic acid to be present in silo feed, it is usually present in the silo at the level of 0.1-0.7%, and this value receives the highest score at the level of 0-1.5% according to German Agricultural Society (Deutsche Landwirtschafts-Gesellschaft, DLG) (DLG, 1987). Similarly, Özaslan (2016) reported that the addition of corn syrup as an easily soluble carbohydrate source to alfalfa silage decreased the silage butyric acid value, which supports the present study.

In this study, when the yeast and mould values of the silages prepared with the addition of almond hulls at different rates to alfalfa plants were examined, a decrease was observed due to the increase in almond hull compared to the control group. In her study,

When the correlation table was examined, it was seen that the negative correlation between AA and yeast values and AA and mould supported this statement. In the study, on the 5th day of aerobic stability, the CO_2 production amounts of the silage groups with almond hull addition ranged between (1.25-2.38) g/kg DM, but a decrease was observed in all trial groups due to the increase in almond hull compared to the control group ($P<0.05$). The highest acetic acid, the lowest yeast and mould amount and the lowest CO_2 ratio level supports the statement reported by Ali et al. (2020) that the amount of acetic acid produced by heterolactic LAB fermentation in silages in the additive groups has an inhibitory effect against microorganisms that cause silage deterioration, prevents the reproduction and activity of yeasts, reduces CO_2 production, in other words, improves aerobic stability values. When the correlation table was examined, it was seen that the negative correlation observed between LA, AA and CO_2 supported this report. Yayla (2019) reported that the addition of waste jam to alfalfa silage reduced the CO_2 value and improved aerobic stability compared to the control group.

When the results obtained in this study were evaluated in terms of all parameters, it was concluded that alfalfa silages prepared with the addition of 6% almond hull had positive effects on silage quality, fermentation characteristics and *in vitro* organic matter digestion, almond hull can be used as silage additive and the best results were obtained with the addition of 6% almond hull.

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