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The Effect of Different Withering Times and Different Additives on the Feed Value of Alfalfa Silage

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A R T I C L E I N F O

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A B S T R A C T

The study was conducted to determine the effects of different withering time and additives on some physical and chemical parameters and feed value of alfalfa (Medicago sativa) silage. In the study, Bilensoy alfalfa variety, 3 different withering times (0, 12 and 24 hours) and 6 different additives (control, 4% cracked barley, 4% cracked wheat, 4% cracked corn, 4% wheat bran and 2% sucrose) were added and 18 subjects were examined. Silages were formed in the laboratory using vacuum bags (25 × 35 cm in size, 110 micron thickness) and vacuum machine, and the packages were kept at room temperature for 2 months for silage maturation. DLG scoring method was used to determine the physical quality of matured silages. For chemical quality and feed value; dry matter (DM), pH, crude protein (CP), crude ash (CA), acid detergent fibre (ADF) and neutral detergent fibre (NDF) values of the silage samples were determined, Fileg score, total digestible nutrients (TDN), dry matter intake (DMI), digestible dry matter (DDM), net energy lactation (NEL) and relative feed value (RFV) were calculated. The prolonged withering period decreased the CP in alfalfa silage, while DLG classification, pH, Fleig score, DM, CA, ADF and NDF increased significantly. The effect of additives added to alfalfa silage on DLG classification was found to be insignificant, but withering increased DLG score significantly. It was determined that the additives decreased, pH, CP, NDF and ADF ratios, increased Fleig score and significantly improved feed value parameters compared to the control group. Withering significantly increased all calculated feed value parameters. As a result, in terms of optimum feed value and alfalfa silage quality, 24 h withering and 4% cracked corn addition can be recommended compared to the other treatments compared.

1. Introduction

Alfalfa is a difficult plant to silage due to its high protein content, low water-soluble carbohydrate level and high buffer capacity (Tatli Seven et al., 2021). The relationship between the withering time and the use of additives in alfalfa silage is critical, especially to optimize fermentation quality and increase nutritional value. The withering time affects the moisture content and thus the fermentation process. Tremblay et al. (2014), who investigated the effect of mowing alfalfa plants in the afternoon and withering until they contained about 35% DM by wide spreading on silage

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fermentation characteristics, reported that withering increased the non-structural carbohydrate content of alfalfa, was well preserved during fermentation, and the silage exhibited lower pH, higher lactic acid concentration, lower volatile fatty acids and NH3-N contents. Dumlu Gül et al. (2015) reported that 12 h withering period and 10% barley addition could significantly improve the physical properties and pH of alfalfa silage. Tremblay et al. (2014), who studied the effect of harvesting alfalfa plants in the afternoon and withering until about 35% DM content by wide spreading on silage fermentation characteristics, reported that withering increased the non-structural carbohydrate content of alfalfa, was well preserved during fermentation, and the silage exhibited lower pH, higher lactic acid concentration, lower volatile fatty acids and NH3-N contents. Dumlu Gül et al. (2015) reported that 12 h withering period and 10% barley addition could significantly improve the physical properties and pH of alfalfa silage. Li et al. (2016) studied the effects of various chemical additives (sucrose, potassium citrate, sodium carbonate, acetic acid, formic acid, propionic acid) on the fermentation quality of alfalfa harvested at high moisture content and reported that potassium citrate and sucrose improved fermentation quality especially when alfalfa was wilted to 30% DM content. This suggests that the withering period should be optimized to increase the effectiveness of the additives, so that the overall quality of the silage can be improved.

It is common to use additives to improve the fermentation process of forage crop silages with high protein and mineral content but low carbohydrate content. Research has shown that specific additives can significantly improve fermentation quality, chemical composition and microbial population during silage production. Wang et al. (2024) reported that the addition of Lactobacillus plantarum as a silage additive to sand acacia (Caragana korshinskii Kom), a legume shrub form, decreased the pH and increased the lactic acid content of silage, while the addition of cellulase and xylenase increased the degradability of structural carbohydrates and supported fermentation quality. In addition, formic acid was reported to improve fermentation quality by supporting the stabilization of red clover silage (Rinne et al., 2024).

Carbohydrate sources such as cereal grains, sucrose, glucose and molasses are used in the production of legume silages because they are economical and improve fermentation quality. Zi et al. (2022) reported that sucrose, glucose or molasses (10g/kg wet weight) increased the lactic acid level and decreased the pH in the silage of stylo (Stylosanthes guianensis), a legume plant, thus increasing silage stability. Similarly, Aydın et al. (2023) reported that the addition of lactic acid bacteria and 1.5% sucrose to alfalfa silage significantly decreased pH compared to the lactic acid bacteria addition group. It is also known that barley (5%) used as an additive in alfalfa silage production significantly improves silage quality (Acar and Bostan, 2016).

Nowadays, there are also a number of studies on the use of bran in legume plant silages (Tian et al., 2018; Çotuk and Önenç, 2017). Tian et al. (2018), who evaluated the effects of lactic acid inoculants on silage quality in alfalfa and wheat bran (0, 10, 15 and 20%) mixture silages, reported that DM content increased, pH and ammonia nitrogen decreased as wheat bran ratio increased, and bran was effective in terms of choosing the right inoculant in the fermentation process of alfalfa silage. In addition, Çotuk and Önenç (2017) reported that the addition of 10% bran significantly increased the quality classification of alfalfa silage in terms of flieg score and physical evaluation score, significantly increased the number of lactobacilli and decreased pH. The researchers reported that the Flieg score of alfalfa silage with no additive and 10% bran additive, which were wilted for 3 hours after harvest, were 61.39 (good quality) and 81.70 (very good quality), respectively. It is a necessary condition for sustainable animal husbandry that the additives used during the silage production of plant species such as alfalfa, which are difficult to silage, should be met from the farm's own production or be economical. The aim of this study was to evaluate the effects of different withering time and additives (cracked barley, cracked wheat, cracked corn, wheat bran and sucrose) on some physical and chemical parameters and feed value of alfalfa silage.

2. Material and Method

Bilensoy alfalfa (*Medicago sativa*) variety was used as silage material in the study. The alfalfa plant used in the experiment was obtained from the application area of Isparta University of Applied Sciences, Faculty of Agriculture. The development of the plant from sowing to harvest time was followed regularly and harvesting was carried out on June 25, 2020 at the middle of flowering. In the study, 3 different withering times (0, 12 and 24 h) were applied after harvest. For each withering period, 1 control (no additive) and 5 experimental groups (4% crushed barley, 4% crushed wheat, 4% crushed maize, 4% wheat bran and 2% sucrose) were formed. The additives consisted of crushed cereals, sucrose or wheat bran used in silage production of plants with high protein content (Zi et al., 2022; Tian et al., 2018; Acar and Bostan, 2016). Withering times of alfalfa were determined in parallel with the studies (Besharati et al., 2000; Acar and Bostan, 2016; Dumlu Gül et al., 2015). The study was carried out on 18 study subjects in a 3 x 6 factorial experimental design. The subjects examined in the study were designed with 3 replicates and a total of 54 silages were formed. The withering process was carried out under natural conditions in the field after harvest (Yang et al., 2022). The additives used in the experiment were proportioned according to the fresh weight of the plant (Li et al., 2016). Average DM (36.24%), CP (22.02%), CA (13.01%), NDF (42.18%) and ADF (28.37%) ratios were determined in alfalfa samples taken before silage. The silage samples of each experimental group were first weighed, additives were added and mixed homogeneously by hand. The silage samples were filled into vacuum bags (25 × 35 cm in size, 110 micron thickness) of approximately 800 g and the air in the bags was removed with the help of an industrial vacuum machine (Ahsan, 2023). The bags were sealed to provide anaerobic environment and the samples were kept at room temperature for 2 months.

Following the maturation period, silage samples of each group were opened and physical quality analyses (color, odor and structure) were performed by three researchers using the DLG (Deutsche Landwirtschafts - Gesellschaft) silage evaluation key (Table 1) and the mean scores were taken (Table 2) (DLG, 1987).

Table 1. DLG silage evaluation key

	Observation	Score
Odor	No buttery acid smell, slightly sour, fruity and bread-like odor	14
	A slight buttery odor, strong sour odor or musty odor	8
	Moderate buttery odor, strong musty odor	4
	Strong buttery odor and ammonia smell	2
	Rotten or foul and strong musty odor	0
Structure	Leaf and stem structure normal	4
	The structure of the leaves is a bit distorted	2
	Leaves and stems have a markedly deformed structure, slightly moldy	1
	Leaves and stems rotten, heavily moldy and heavily soiled	0
Color	Green forage color (slightly brownish in wilted silage)	2
	Yellow or dusky brown	1
	The color has changed a lot, light yellow or very dark	0

Table 2. Total DLG (Deutsche Landwirtschafts - Gesellschaft) score evaluation criteria.

Total DLG Score	Silage Quality Class	Average Nutrient Loss
18-20	Very Good Quality	10-15%
14-17	Good Quality	15-20%
10-13	Medium Quality	20-25%
5-9	Low Quality (Poor Quality)	25-50%
0-4	Very Low Quality (Degraded)	≥50%

In the study, pH was determined by modifying the method of Akbay et al. Twenty g of silage sample from each replicate was treated with 180 ml of distilled water for 2-3 min in a mixer and filtered through a double layer of cheesecloth. The pH levels of the silage filtrates were measured using a digital pH meter (Thermo Orion Star, serial no: B39604). DM, CA and CP analyses of the silage samples of the groups were determined according to the method reported in AOAC (2000), while NDF and ADF analyses were determined using an automatic analyzer (ANKOM 220 Fiber Analyzer, serial no: # A220220035) according to the method reported in Van Soest et al., (1991). NDF solution was prepared by adding 120 g FND20C/1 and 20 ml triethylene glycol FND20C/2 to 1.8 liters of distilled water and stirred with a magnetic stirrer (Wisestir MSH-20A, Serial no: 0400985129J040) until dissolved and completed with 2 liters of distilled water. ADF solution was prepared by dissolving 40 g CTAB (Cetyltrimethylammoniumbromide) in 2 liters of 1.0 normal H_2SO_4 with the same magnetic stirrer. The following formulae adapted from various sources were used to calculate net energy lactation (NEL), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and total digestible nutrients (TDN) (NRC, 2001; Horrocks and Vallentine, 1999; Van Soest, 1994; USDA, 1980; Rohweder et al., 1978). Flieg score was calculated according to the method reported by Moselhy et al. (2015).

$$\text{Flieg score} = 220 + (2 \times \text{DM (\%)} - 15) - (40 \times \text{pH value})$$

$$\text{NEL (Mcal/kg)} = (1.044 - (0.0119 \times \text{ADF})) \times 2.205$$

$$\text{DDM (\%)} = 88.9 - (0.779 \times \text{ADF}$$

$$\text{DMI (\% body weight)} = 120 \div \text{NDF}$$

$$\text{RFV} = \text{DDM (\%)} \times \text{DMI (\%)} \times 0.775$$

$$\text{TDN} = (-1.291 \times \text{ADF}) + 101.35$$

Relative feed value is a criterion used in the evaluation and marketing of roughages and <75 indicates poor quality; 75-86 indicates 4th quality; 87-102 indicates 3rd quality; 103-124 indicates 2nd quality; 125-151 indicates good quality and >151 indicates 1st quality (Kılıç and Abdiwali, 2016). The quality classification of the silages was made according to the Flieg score sheet (Moselhy et al., 2015) shown in Table 3. The data of the experiment were subjected to analysis of variance using SAS (1998) computer programme according to factorial completely randomized design. When significant differences were found as a result of statistical analysis, Duncan test was applied at 5% significance level for comparison of means.

Table 3. Flieg score sheet

Score range	Silage Quality Class
20 points and below	Very poor quality
21-40 points	Low quality
41-60 points	Medium quality
61-80 points	Good quality
81 points and above	Very good quality

3. Results and Discussion

In the study, withering significantly increased the DLG score (Table 4) of alfalfa silage ($p<0.05$), while additives and additive x withering interaction were statistically insignificant. When the mean values of the withering times were analyzed, the DLG score was determined as 18.44 in alfalfa silages made without withering, while the DLG scores were determined as 19.46 and 19.70 after 12 and 24 hours of withering, respectively. When the mean values of the additives were analyzed, they were statistically insignificant and the DLG scores obtained varied between 18.59 and 19.92. The DLG scores determined in the experiment were classified as very good quality. Dumlu Gül et al. (2015) reported that harvest time (early and late flowering), withering (12 h) and addition of additives (5% molasses and 10% cracked barley) positively affected the physical properties of silage. Acar and Bostan (2016) also reported that the physical quality of alfalfa silage withered for 24 h and 5% barley added was in the very good quality class (19 points). These studies are in parallel with the findings of the research in terms of withering time.

Table 4. Effect of withering time and different additives on the physical properties of alfalfa silage

Additive	Odor				Color			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	

Control	12.44	13.44	13.78	13.22	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Cracked Barley	11.89	13.67	13.89	13.15	1.43^{b}	2.00^{a}	2.00^{a}	1.81 b
Cracked Wheat	13.44	13.56	13.22	13.41	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Cracked Corn	13.78	14.00	14.00	13.93	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Wheat Bran	12.67	12.78	14.00	13.15	1.30^{b}	2.00^{a}	2.00^{a}	1.77 b
Sucrose	13.67	13.56	14.00	13.74	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Means	12.99 b	13.50 ab	13.81 a		1.79 b	2.00 a	2.00 a	
	Wit: *; Add: ns; WxA: ns				Wit: **; Add: **; WxA: **			

Additive	Structure				DLG			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	3.44	3.78	4.00	3.74	17.89	19.22	19.78	18.96
Cracked Barley	2.89	4.00	4.00	3.63	16.22	19.67	19.89	18.59
Cracked Wheat	4.00	4.00	3.67	3.89	19.44	19.56	18.89	19.30
Cracked Corn	4.00	4.00	4.00	4.00	19.78	20.00	20.00	19.93
Wheat Bran	3.67	4.00	3.67	3.78	17.67	18.78	19.67	18.70
Sucrose	4.00	4.00	4.00	4.00	19.67	19.56	20.00	19.74
Means	3.66 b	3.96 a	3.89 ab		18.44 b	19.46 a	19.70 a	
	Wit: *; Add: ns; WxA: ns				Wit: **; Add: ns; WxA: ns			

Wit: Withering; Add: Additive; ns: Non significant; *: $P<0.05$; **: $P<0.01$

The effects of withering time and different additives on pH, some nutrient ingredients, Fleig score and quality classification of alfalfa silage are shown in Table 5. In the study, withering time and additive use significantly increased the DM ($p<0.01$) and decreased the pH ($p<0.01$) of alfalfa silages. The effects of withering time and additive treatments on ratios of CP, CA, DM, NDF, ADF and NEL level were statistically significant at 1% level. It was determined that the effect of withering time and additive interactions on DM, CA, ADF and NEL was at $p<0.01$ level, while it was at $P<0.05$ level on CP.

Table 5. Effect of withering time and different additives on pH, DM, Flieg score, CP, CA, ADF, NDF and NEL of alfalfa silage, % in DM

Additive	DM				pH			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	$31.37^{\imath}$	38.57^{e}	43.60^{b}	37.85 c	4.82^{a}	4.81^{a}	4.83^{a}	4.82 a
Cracked Barley	35.70^{gh}	42.19^{c}	46.26^{a}	41.38 a	$4.73^{b\text{-}d}$	4.74^{bc}	4.75^{b}	4.74 c
Cracked Wheat	37.24^{f}	40.79^{d}	45.87^{a}	41.29 a	4.64^{g}	$4.70^{d\text{-}f}$	$4.70^{d\text{-}f}$	4.68 d
Cracked Corn	36.19^{fg}	42.47^{c}	46.23^{a}	41.63 a	$4.6^{\ h}$	$4.59^{h\imath}$	$4.56^{\imath}$	4.58 e
Wheat Bran	35.90^{gh}	41.69^{cd}	45.99^{a}	41.22 a	$4.74^{b\text{-}d}$	4.75^{bc}	4.83^{a}	4.77 b
Sucrose	34.95^{h}	41.47^{cd}	44.41^{b}	40.27 b	4.67^{fg}	4.68^{ef}	$4.70^{c\text{-}e}$	4.69 d
Means	35.24 c	41.20 b	45.39 a		4.70 b	4.71 b	4.73 a	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: **			
Additive	CP				Fleig			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	23.57^{a}	23.00^{b}	22.50^{bc}	23.02 a	74.8^{h}	89.6^{g}	98.9^{e}	87.8 d
Cracked Barley	$22.47^{b\text{-}d}$	$22.10^{c\text{-}e}$	$21.90^{c\text{-}f}$	22.15 b	87.2^{g}	99.7^{e}	107.2^{bc}	98.0 c
Cracked Wheat	22.50^{bc}	$22.03^{c\text{-}e}$	$21.97^{c\text{-}e}$	22.16 b	93.7^{f}	98.5^{e}	108.6^{b}	100.3 b
Cracked Corn	$21.60^{e\text{-}g}$	$21.83^{d\text{-}f}$	21.20^{gh}	21.54 c	93.1^{f}	$106.5^{b\text{-}d}$	115.2^{a}	104.9 a
Wheat Bran	$22.40^{b\text{-}d}$	22.80^{b}	22.90^{b}	22.70 a	87.4^{g}	98.5^{e}	103.8^{d}	96.6 c
Sucrose	21.10^{gh}	$21.33^{f\text{-}h}$	20.83^{h}	21.09 d	88.2^{g}	100.7^{e}	105.2^{cd}	98.0 c
Means	22.27 a	22.18 a	21.88 b		87.4 c	98.9 b	106.5 a	
	Wit: **; Add: **; WxA: *				Wit: **; Add: **; WxA: **			
Additive	NDF				ADF			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	36.97	38.30	37.73	37.66 a	24.73^{cd}	$26.69^{a\text{-}c}$	28.51^{a}	26.64 a

Cracked Barley	35.50	37.33	38.00	36.94 ab	25.53^{b-d}	26.04^{b-d}	25.57^{b-d}	25.71 ab
Cracked Wheat	35.67	37.70	37.37	36.91 ab	25.01^{b-d}	25.39^{b-d}	24.87^{b-d}	25.09 b
Cracked Corn	34.30	35.80	37.10	35.73 c	20.53^{g}	25.06^{b-d}	25.15^{b-d}	23.58 c
Wheat Bran	36.43	37.97	38.40	37.60 a	24.27^{de}	26.79^{ab}	28.33^{a}	26.46 a
Sucrose	36.07	36.43	36.77	36.42 bc	21.84^{fg}	22.59^{ef}	24.27^{de}	22.89 c
Means	35.82 b	37.26 a	37.56 a		23.65 c	25.43 b	26.12 a	
	Wit: **; Add: **; WxA: ns				Wit: **; Add: **; WxA: **			

Additive	NEL				CA			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	1.65^{d}	1.60^{ef}	1.55^{g}	1.60 c	12.60^{b}	12.50^{b-d}	12.00^{g-j}	12.36 b
Cracked Barley	1.63^{de}	1.62^{de}	1.63^{de}	1.62 bc	12.27^{d-g}	11.97^{h-j}	11.97^{h-j}	12.06 c
Cracked Wheat	1.65^{d}	1.64^{de}	1.65^{d}	1.64 b	12.20^{e-h}	12.40^{b-e}	12.17^{e-i}	12.25 b
Cracked Corn	1.76^{a}	1.64^{de}	1.64^{de}	1.68 a	11.83^{j}	12.10^{f-j}	11.90^{ij}	11.94 c
Wheat Bran	1.67^{cd}	1.60^{ef}	1.56^{fg}	1.60 c	12.30^{c-f}	13.17^{a}	12.53^{bc}	12.66 a
Sucrose	1.73^{ab}	1.71^{bc}	1.67^{cd}	1.70 a	12.20^{e-h}	12.17^{e-i}	11.83^{j}	12.06 c
Means	1.68 a	1.64 b	1.62 c		12.23 b	12.38 a	12.07 c	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: **			

DM: Dry mater; CP: Crude protein; CA: Crude ash; ADF: Acid detergent fiber; NDF: Neutral detergent fiber; NEL: Net energy lactation (Mcal/kg); Wit: Withering; Add: Additive; ns: Non significant; *: $P<0.05$; **: $P<0.01$

In the study, it was determined that the addition of additives and both withering times (12 and 24 h) significantly increased the DM content of alfalfa silage ($P<0.01$) and the interactions between them were significant. Both withering times and additives had a positive effect on DM in alfalfa silages, but fluctuations and intersections in the values caused the withering time x additive interaction to be significant. The lowest value was obtained from 0 h x control combination and the highest values were obtained from 24 h x cracked barley, 24 h x cracked wheat, 24 h x cracked corn and 24 h x wheat bran combinations. Similar to the findings of this study, the DM content of alfalfa silage withered for 12 h decreased significantly and the interaction between the withering time and the addition of additives (barley, molasses) was found to be significant (Dumlu Gül et al., 2015). Researches evaluating the effects of various additives added to alfalfa silage on silage quality (Li et al., 2016) and feed value (Mariotti et al., 2020) preferred to wither the DM of alfalfa to 30% and 38%, respectively, which supports the findings of the study.

In the study, prolonging the withering time significantly increased the silage pH, but all additives significantly decreased the silage pH compared to the control group (4.82). However, the lowest pH levels were recorded in the 4% crushed corn, 4% crushed wheat and 2% sucrose supplemented groups with 4.58, 4.68 and 4.69, respectively. Terms related to the withering time x additive interaction of pH values are shown as pH values obtained as a result of the applications change between 4.56-4.83. In general, additive treatments increased pH values depending on withering times in alfalfa, while the decrease in pH value as a result of cracked corn treatment caused the interaction to be significant. However, Dumlu Gül et al. (2015) reported that both withering and additive treatments decreased pH. While the results obtained by the researchers from the additive application were in agreement with our findings, the results obtained as a result of withering were inconsistent with our findings. All treatments were found to be statisticaly significant in terms of Fleig score ($p<0.01$). While both withering times increased the Flieg score, all additive groups had higher Flieg scores compared to the control group. Withering time x additive interaction was found to be significant in terms of fleg score, withering times and additive treatments increasing fleg score value. Although this increase generally showed a linear trend, the values calculated in additive treated silages had different increase rates depending on the withering time. In the present study, fleg score values varied between 74.8 and 115.2, the lowest value was determined in the 0 h x control combination, and the highest value was determined in the 24 h x cracked corn combination. In parallel with the findings of present study, it was reported that the Flieg scores of alfalfa silage were 90.87 (very good quality) and 61.39 (good quality) at the end of twenty-four hours (Besharati et al., 2000) and three hours (Çotuk and Önenç, 2017) withering, respectively. Naturally, Fleig score increases as the DM value of the silage sample increases and pH value decreases. The Fleig score results of the study groups are in parallel with the data. Withering of alfalfa for 24 h significantly decreased the CP and CA ratios of the silage and increased the ADF and NDF ratios. CP varied between 21.88% and 22.27%, CA between 12.06% and 12.38%, NDF between 35.82% and 37.56% and ADF between 23.65% and 26.11% according to withering periods. It was determined that the addition of cracked wheat, cracked corn and sucrose to alfalfa silage significantly decreased silage ADF, while the addition of cracked corn and sucrose significantly decreased silage NDF. According to the results of additives to alfalfa silage, CP varied between 21.08% and 23.02%, CA between 11.94% and 12.66%, NDF between 35.71% and 37.66% and ADF between 22.89% and 26.64%.

There is statistical significance in the withering time x additive interaction of CP, CA and ADF ratios. This situation is due to the differences in the increase and decrease rates of the values in the silage samples treated with additives depending on the withering time of CP, CA and ADF properties. The intersection points caused the withering time x additive interaction to be significant. In this context, Aydın et al. (2023) reported that the addition of lactobacilli and 1.5% sucrose had no effect on the CP content of alfalfa silage, whereas Çotuk and Önenç (2017) stated that the inclusion of 10% bran increased the CP level of silage. Furthermore, Mariotti et al. (2020) found that the addition of increasing levels of whey (7.5%, 15%, and 30%) to withered alfalfa (38%) significantly reduced the DM, ADF, and NDF contents of the silage. These findings highlight the complex interactions between withering time and additive effects on silage composition, further emphasizing the significance of the observed statistical interactions. It is clear that the effect of withering and additive on silage DM content may be related to their effects on fermentation, as well as the DM content of the additive used is also related to silage DM. As a matter of fact, in the present study, withering and additive interactions were found to be significant in terms of DM and ADF values, and the addition of 4% crushed cereals to alfalfa silage increased DM content and decreased ADF and NDF values significantly compared to the control group. The fact that the interaction between withering time and additive was insignificant in terms of NDF value is similar to Dumlu Gül et al. (2015) who applied 12 hours of withering to alfalfa silage. Acar and Bostan, (2016) who applied withering to alfalfa (24 hours) and those who did not (Aydın et al., 2023; Tian et al., 2018; Çotuk et al., 2017) reported that the addition of additives (molasses, barley, lactobacilli, bran, whey and sucrose) significantly decreased silage ADF and NDF ratios, supporting the findings of the present study.

The effects of withering time and different additives on the feed value of alfalfa silage are shown in Table 6. In terms of the analyzed feed value parameters (TDN, DMI, DDM and RFV), withering time and additive treatments were statistically significant at 1% level. It was determined that the effect of withering time x additive on TDM and DDM values was significant at P<0.01 level, while the effect on DMI and RFV values was insignificant. While the increase in withering time decreased the feed value parameters, it was observed that the additive treatments except wheat bran addition had better values compared to the control group. It was determined that the highest values in terms of TDN, DDM and RFV were obtained in the cracked corn and sucrose added groups, while the cracked corn added group had the highest value in terms of DMI.

Table 6. Effect of withering time and different additives on feed value of alfalfa silage, % in DM

Additive	TDN				DMI			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	69.42^{de}	66.89^{e-g}	64.54^{g}	66.95 c	3.25	3.13	3.18	3.18 c
Cracked Barley	68.40^{d-f}	67.73^{d-f}	68.33^{d-f}	68.15 bc	3.38	3.22	3.16	3.25 bc
Cracked Wheat	69.06^{d-f}	68.58^{d-f}	69.24^{d-f}	68.95 b	3.37	3.18	3.21	3.25 bc
Cracked Corn	74.84^{a}	69.00^{d-f}	68.88^{d-f}	70.90 a	3.50	3.35	3.23	3.36 a
Wheat Bran	70.02^{cd}	66.77^{fg}	64.78^{g}	67.19 c	3.29	3.16	3.13	3.19 c
Sucrose	73.15 ab	72.19 bc	70.02 cd	71.78 a	3.33	3.29	3.26	3.29 b
Means	70.81 a	68.53 b	67.63 c		3.35 a	3.22 b	3.20 b	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: ns			
Additive	DDM				RFV			

	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	69.63^{de}	68.11^{e-g}	66.69^{g}	68.14 c	175.3	165.4	164.4	168.4 c
Cracked Barley	69.02^{d-f}	68.61^{d-f}	68.98^{d-f}	68.86 bc	180.9	171.1	168.9	173.7 b
Cracked Wheat	69.42^{d-f}	69.12^{d-f}	69.52^{d-f}	69.35 b	181.0	170.5	173.0	174.9 b
Cracked Corn	72.90^{a}	69.38^{d-f}	69.31^{d-f}	70.53 a	197.9	180.4	173.7	184.0 a
Wheat Bran	70.00^{cd}	68.03^{fg}	66.83^{g}	68.28 c	178.7	166.6	161.9	169.1 c
Sucrose	71.89^{ab}	71.30^{bc}	70.00^{cd}	71.06 a	185.4	182.0	177.1	181.5 a
Means	70.48 a	69.09 b	68.55 c		183.2 a	172.7 b	169.8 b	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: ns			

TDN: Total digestible nutrients (%); DMI: Dry matter intake (% body weight); DDM: Digestible dry matter (%); RFV: Relative feed value; Wit: Withering; Add: Additive; ns: Non significant; *: P<0.05; **: P<0.01

In the literature, no study was found in which the effects of withering time and additives on the feed value of alfalfa silage were evaluated together. Acar and Bostan (2016) reported that molasses, barley or whey added to alfalfa silage withered for 24 hours improved the DDM, DMI, RFV and TDN of silage compared to the control group. In parallel with the research findings, Mariotti et al. (2020) reported that whey (15% and 30%) added to alfalfa wilted to 38% DM decreased NDF and ADF ratios while improving TDN and RFV values of silage.

4. Conclusion

It is clear that withering time and the water soluble carbohydrate content of the plant during the silage maturation process affect silage quality. Optimum withering time will provide a stable fermentation environment by balancing the water content, but prolonged withering time may lead to nutrient losses. In the study, it was observed that withering significantly increased the DLG score of alfalfa silage, but the interaction between additive addition and withering was insignificant in terms of DLG score. While the quality classification was high in the experimental groups, the interaction between withering time and additive was found to be significant in terms of NDF value. In particular, it was determined that 12 hours of withering time had no effect on pH, but 24 hours of withering time significantly decreased silage pH with the addition of additive. This may be due to the fact that prolonged withering improves the fermentation environment and increases the activity of lactic acid bacteria. In the study, the addition of 4% cracked wheat or cracked corn and 2% sucrose significantly decreased silage ADF and NDF values. However, ADF value was found to be significant while NDF value was found to be insignificant in terms of withering additive interaction. When all the results of the study were analyzed, it was observed that the prolongation of the withering period decreased the CP rate of alfalfa silage and significantly increased the DLG classification, Fleig score, DM ratio, pH, CA, ADF and NDF ratios. On the other hand, the additives decreased DLG classification, pH, CP, NDF and ADF ratios of alfalfa silage compared to the control group, increased Fleig score and CA ratio and significantly improved feed value parameters. As a result, it is seen that withering application is beneficial in alfalfa silage production to obtain better quality silage, while the addition of additives is important. In terms of withering time in alfalfa silage production, it was concluded that 24 hours of withering and 4% cracked corn addition were suitable for optimum silage quality and feed value parameters.

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