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RESEARCH ARTICLE

The Effects of Ensiling Sunflower with Different Ratios of Sugar Beet Pulp and Bacterial Inoculant+Enzyme Additives on Silage Quality, In vitro Digestibility and Energy Content

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Abstract

S. YILDIZ. 2025. The Effects of Ensiling Sunflower with Different Ratios of Sugar Beet Pulp and Bacterial Inoculant+Enzyme Additives on Silage Quality, In vitro Digestibility and Energy Content. Int. J. Agric. Nat. Resour. 1-10. This study investigated the effects of the addition of different additives to ensiled headless confectionary sunflower crops (HCSC) on silage quality, in vitro digestibility (IVD), and energy content. HCSC was pulled into pieces and mixed with sugar beet pulp (SBP) at ratios of 0, 10, 20, and 30%, and a bacterial inoculant+enzyme mixture (BI+E) was added to these groups at a ratio of 0 or 5 $g.ton^{-1}$. The pH values; ammonia nitrogen (NH_3-N) and volatile fatty acid (VFA) concentrations of the silages; and raw nutrient parameters, IVD, energy content, relative feed value (RFV) and Fleig scores were subsequently determined. SBP increased the OM and CP levels and lowered the DM, CA, EE, NDF, and ADF levels of the silages. BI+E increased the OM, CP, NDF, and ADF levels ($p<0.05$). The effect of the SBPxBI+E interaction on nutrient contents was significant only for the CP and EE values ($p<0.05$). SBP supplementation increased the AA and PA values. BI+E increased the values of all the parameters except for LA ($p<0.05$). The effects of the SBPxBI+E interaction on fermentation values were significant except for those of PA ($p<0.05$). Significant changes were observed in RFV and IVD by the addition of SBP, in Fleig scores by the addition of BI+E, and in IVD, RFV and Fleig scores by the interaction of SBPxBI+E ($p<0.05$). In the case of adding BI+E to HCSCs, it would be more appropriate to ensile it with a carbohydrate source such as SBP, and adding SBP to this material at a ratio of up to 30% is recommended.

Keywords: Headless confectionary sunflower, silage quality, relative feed value

Highlights

- Waste materials remaining at the end of agricultural activities can be converted into quality ruminant animal feed using additives such as sugar beet pulp and BI+E.
- In this study, the importance of using additives in obtaining quality silage has been revealed.
- It has been determined that BI+E additive can be used alone or together with easily soluble carbohydrate sources.
- In this study, good and excellent quality silages

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were obtained and it was concluded that these silages can be used as alternative roughage sources in the nutrition of ruminants.

Introduction

In Türkiye, the poor performance of animal production is due mainly to the nutritional deficit of feed, which directly impacts animals by not adequately meeting their nutritional needs. The most important problems related to feed are its high cost and the lack of sufficient production of quality roughage. Input for feed accounts for 70% of the cost of animal husbandry businesses. For this reason, developments that could meet the needs of the animal husbandry sector in Türkiye and improve productivity and profitability strongly depend on the ability of producers to meet quality roughage requirements, as well as other factors (Gül & Hasdemir, 2012).

One of these strategies involves the use of sunflower (*Helianthus annuus L.*), an alternative feed crop that is important for agriculture in Türkiye because of its multiple advantages. Sunflower has a wide range of uses, including oil production, and functions as a confectionary crop, ornamental plant, silage material, and feed for ruminants and birds. While sunflower crops are grown for silage-making in many parts of the world, their cultivation for this reason is not very prevalent in Türkiye. Because sunflower has the potential to be easily ensiled, like maize, it can be used alone or in the form of a supplement for feed materials that are difficult to ensile (Yıldız & Erdoğan 2018). One of the methods for utilizing sunflower as feed is to produce silages from stems and flower heads without seeds that are left behind after harvesting. It has been reported that good-quality silages can be obtained from sunflower stems and flower heads and their mixtures with other plants (Konca, 2015).

As silage additives, enzymes can be added to silages alone or in a mixture with bacterial inoculants. Enzymes partially digest plant cell walls, releasing monomers of sugars that contribute to LAB fermentation, reducing pH, and concomitantly improving the digestibility of the ensiled material (Kung, 2014). One of the options for improving the nutritional quality of silage is the addition of SBP, which is used as an economical feed source for ruminants in locations near sugar refineries. The high moisture content of SBP prevents its long-term storage. When stored in bulk under improper conditions, it can spoil due to undesirable fermentation and mold, which can result in the loss of 40–60% of its nutrient content. The ensiling technique prevents these losses and allows the use of SBP for a longer time (Ülger et al., 2015).

This study aimed to determine the most suitable silage-making process for headless confectionary sunflower crops (HCSCs) by adding SBP at ratios of 0, 10, 20, and 30% and a BI+E mixture at dosages of 0 or 5 g.ton^{-1}. The nutrient content, IVD, energy content, Fleig scores, and RFV of the silage samples were determined.

Materials and methods

The headless confectionary sunflower crop used in the study was obtained from a grower in the Gevaş district of Van Province. The bacterial BI+E mixture (Sil-All 4×4, Lallemand Animal Nutrition UK Ltd.) was obtained from commercial sellers, and the SBP was obtained from Muş Şeker Üretim Sanayi AŞ. A 2×4 factorial trial design was utilized to perform the study. After the heads were removed, the sunflowers were mowed and shredded into silage material. A total of 40 silage samples were filled into 1-liter glass jars with 0, 10, 20 and 30% SBP and 0 and 5 g.ton^{-1} BI+E mixtures. The lids of the glass jars were pierced, and the jars were turned upside down to allow silo water drainage for 48 hours. Then, the perforated lids were resealed with duct tape. The jars were reopened after 70 days of incubation.

Immediately after the silage jars were opened, the pH values of the silage liquids were measured with a digital pH meter. All samples were dried at 65 °C for 48 hours and ground to 1 mm particles in a laboratory-type mill. Dry matter (DM), crude protein (CP) and crude ash (CA) analyses of the silage materials were conducted according to the Weende analysis system (AOAC, 1990), whereas ADF and NDF analyses were conducted according to the methods suggested by Goering and Van Soest (1970). The distillation method was used to calculate the NH_3-N concentrations of the silage fluids (Markham, 1942). The acetic, (AA), propionic, (PA), butyric, (BA) and lactic acid (LA) levels of the silage liquids were identified using high-performance liquid chromatography (HPLC) with an Agilent Hi-Plex organic acid column (Suzuki & Lund, 1980).

The Fleig scores of the silages were calculated according to the method reported by Kılıç (1986) with the following equation: Fleig score=220+(2×%DM-15) -40×pH. The in vitro DMD (dry matter digestibility) and OMD (organic matter digestibility) of the silage samples were determined with an ANKOM DAISY II INCUBATOR device by using the following formula (Ankom, 2002).

In vitro digestibility, % (IVD) = 100 – ((W3 - (W1 × C1)) × 100)/W2

where W1 represents the weight of the filter bag, W2 represents the weight of the sample, W3 represents the final weight after NDF analysis, and C1 represents the bag without sample, which was prepared for correction.

To determine the energy contents of the silages, formulas reported by NRC, (1989) and (Ishler et al. 2000) were used.

DE = digestible energy, $Mcal.kg^{-1}$ DM

DE = TDN% (OMD) × 0.04409

ME, metabolic energy, $kcal.kg^{-1}$ DM

ME = DE × 0.082

NE_L, net energy lactation, $Mcal.kg^{-1}$ DM

NE_L = (%TDN(OMD) × 0.0245) - 0.12

The relative feed value (RFV) method, which was developed in the US for quality control of alfalfa plants, is now being used for all plants. The calculation of RFV is based on the ADF and NDF values of the roughage and the estimation of the potential consumption of the roughage by the animal and the energy it provides. Accordingly, the RFV for alfalfa is assumed to be 100. According to Van Dyke and Anderson (2000), for the formulas required to calculate RFV, first, the digestible dry matter (DDM) value is calculated using the ADF value.

% DDM = 88.9 - (0.779 * % ADF)

The NDF value was used to determine the dry matter yield (DMY) according to the live weight of the animal.

% DMY = 120/NDF

The DDM and DMY values are used in the formula to calculate RFV.

RFV = (% DDM) * (% DMY) * (0.775)

The general linear model (GLM) procedures in the statistical software program SPSS (ver. 13) were used to determine the interactions and differences in the means of the groups in this study. Duncan's multiple comparison test was used to determine the significant differences between the groups. The significance levels of the results obtained were evaluated at $p<0.05$.

Results

The nutrient contents of the HCSC and other mixtures before ensiling and those of the SBP are shown in Table 1.

Table 1. Nutrient Contents (DM, %) before Ensiling

Groups	DM, %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
1-Control (HCSC) +%0 SBP + 0 g.ton^{-1} BI-E	24.16	89.61	10.39	5.64	1.74	49.63	33.88
2-Control + %10 SBP + 0 g.ton^{-1} BI-E	23.70	88.84	11.16	6.32	1.88	49.85	34.74
3-Control + %20 SBP + 0 g.ton^{-1} BI-E	23.58	90.83	9.17	5.93	1.37	53.18	35.36
4-Control + %30 SBP + 0 g.ton^{-1} BI-E	21.09	91.15	8.85	6.33	1.30	50.92	31.98
5-Control + % 0 SBP + 5 g.ton^{-1} BI-E	23.29	88.93	11.07	6.09	1.37	52.17	37.92
6-Control + %10 SBP + 5 g.ton^{-1} BI-E	22.87	89.08	10.92	5.74	1.60	50.75	35.60
7-Control + %20 SBP + 5 g.ton^{-1} BI-E	22.19	89.84	10.16	6.62	1.48	55.99	37.24
8-Control + %30 SBP + 5 g.ton^{-1} BI-E	22.21	90.64	9.36	6.31	1.02	52.11	33.90
SBP	16.50	96.21	3.79	8.17	1.03	51.52	24.25

DM: dry matter, OM: organic matter, CA: crude ash, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber.

Table 2. Nutrient Contents (DM, %) of the Silages

SBP		N	DM %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
SBP 0		10	25.29±0.27a	88.57±0.14c	11.43±0.14a	6.47±0.21b	2.30±0.14	54.89±0.58a	39.50±0.84a
SBP 10		10	24.31±0.33b	88.56±0.13c	11.36±0.12a	6.22±0.05b	2.20±0.12	50.52±0.97b	36.20±0.75b
SBP 20		10	23.91±0.28b	88.98±0.09b	11.02±0.09b	6.45±0.09b	2.15±0.09	52.64±0.97b	37.01±0.97b
SBP 30		10	22.04±0.78c	89.52±0.10a	10.48±0.10c	7.20±0.20a	2.12±0.09	51.04±0.65b	35.47±0.56b
p value			0.000	0.000	0.000	0.000	0.526	0.001	0.002
BIE									
0 g.ton^{-1} BIE		20	24.31±0.26	89.17±0.09	10.83±0.09	6.31±0.08	2.22±0.08	51.23±0.66	35.93±0.55
5 g.ton^{-1} BIE		20	23.83±0.30	88.65±0.12	11.31±0.12	6.88±0.16	2.17±0.07	53.46±0.59	38.16±0.64
p value			0.111	0.000	0.000	0.000	0.590	0.004	0.004
SBP x BIE			0.963	0.261	0.337	0.000	0.001	0.210	0.394
SBP 0	0 BIE	5	25.54±0.40	88.90±0.10	11.10±0.10	5.88±0.07	2.02±0.19	54.25±0.76	38,21±0,59
	5 BIE	5	25.14±0.39	88. 25±0.15	11.75±0.15	7.05±0.15	2.58±0.09	55.53±0.85	40,78±1,43
p value			0.611	0.007	0.007	0.000	0.029	0.296	0.133
SBP 10	0 BIE	5	24.67±0.30	88.90±0.11	11.10±0.11	6.14±0.07	2.46±0.12	48.55±0.75	34,76±0,77
	5 BIE	5	23.95±0.56	88.23±0.11	11.69±0.08	6.29±0.07	1.94±0.12	52.97±1.03	37,64±0,95
p value			0.292	0.002	0.004	0.016	0.016	0.009	0.046
SBP 20	0 BIE	5	24.12±0.30	89.23±0.08	10.77±0.08	6.53±0.08	2.33±0.12	51.20±1.28	35,34±1,39
	5 BIE	5	23.69±0.49	88.73±0.04	11.27±0.04	6.35±0.18	1.97±0.09	54.09±1.24	38,69±0,93
p value			0.472	0.000	0.000	0.377	0.044	0.145	0.081
SBP 30	0 BIE	5	23.01±0.41	89.66±0.11	10.34±0.11	6.68±0.10	2.06±0.14	50.90±1.18	35,41±1,00
	5 BIE	5	22.55±0.37	89.38±0.14	10.62±0.14	7.72±0.20	2.18±0.11	51.17±0.73	35,53±0,65
p value			0.429	0.174	0.174	0.002	0.505	0.850	0.921

DM: dry matter, OM: organic matter, CA: crude ash, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber. a, b, c: Means with different superscripts in the same column are significantly different ($p<0.05$).

Before ensiling, the highest DM control, CA, and EE values were detected in the C+10%SBP+0 g.ton^{-1} BI-E group, the highest CP and NDF values were detected in the C+20%SBP+5 g.ton^{-1} BI-E group, and the highest ADF values were detected in the C+0%SBP+5 g.ton^{-1} BI-E group. The nutrient contents of the headless confectionery sunflower seed silages are given in Table 2.

In terms of the nutrient contents of the HCSC silages, the effects of adding SBP were determined to be significant, except for EE ($p<0.05$). Similarly, the effects of the BI+E doses used in the trial were significant, except on DM and EE ($p<0.05$). Additionally, the effect of the SBPxBI+E interaction on nutrient contents was significant only for CP and EE values ($p<0.05$). The fermentation quality parameter values of the HCSC silages are shown in Table 3.

Fermentation parameters are among the important criteria that determine the quality of silages. In this study, the effects of adding SBP to the silages on fermentation parameter values were significant, except for NH_3-N, whereas the effects of the BI+E doses were significant for all fermentation parameters except for NH_3-N as a percentage of total N ($p<0.05$). Furthermore, the SBPxBI+E interaction had a significant effect on all fermentation parameters of the silages, except for PA ($p<0.05$). The energy content, in vitro digestibility, RFV levels and Fleig scores of the HCSC silages are shown in Table 4.

The effect of adding SBP to the differences

Table 3. Fermentation Parameters of the Silages

SBP			pH	NH_3-N mg.dl^{-1}	NH_3-N % of Total N	LA, %	AA, %	PA, %
SBP 0		10	4.46±0.04a	66.47±2.22	18.21±0.47ab	2.75±0.12a	1.17±0.07d	0.20±0.007c
SBP 10		10	4.49±0.06a	68.33±2.43	19.32±0.64a	2.78±0.28a	1.54±0.09c	0.49±0.05b
SBP 20		10	4.36±0.03b	65.47±1.25	18.03±0.46b	2.51±0.09b	1.84±0.09b	0.53±0.07b
SBP 30		10	4.32±0.03b	63.45±1.38	15.74±0.59c	2.63±0.12ab	2.02±0.05a	0.65±0.02a
p value			0.000	0.096	0.000	0.026	0.000	0.000
BIE								
0 g.ton^{-1} BIE		20	4.30±0.02	63.39±0.71	17.55±0.27	3.01±0.10	1.53±0.09	0.38±0.05
5 g.ton^{-1} BIE		20	4.51±0.03	68.42±1.51	18.02±0.65	2.31±0.06	1.77±0.09	0.58±0.04
p value			0.000	0.001	0.411	0.000	0.001	0.000
SBP x BIE			0.008	0.007	0.000	0.000	0.010	0.096
SBP 0	0 BIE	5	4.33±0.02	61.69±0.55	18.37±0.28	3.01±0.11	1.11±0.12	0,02±0,01
	5 BIE	5	4.58±0.02	71.24±2.75	18.06±0.96	2.43±0.09	1.24±0.06	0,30±0,05
p value			0.000	0.014	0.773	0.005	0.416	0.016
SBP 10	0 BIE	5	4.33±0.04	63.60±2.76	18.16±0.89	3.62±0.10	1.32±0.04	0,38±0,03
	5 BIE	5	4.64±0.03	73.06±2.26	20.48±0.46	2.11±0.12	1.75±0.12	0,61±0,07
p value			0.000	0.038	0.059	0.000	0.009	0.013
SBP 20	0 BIE	5	4.29±0.03	62.95±0.87	16.90±0.37	2.60±0.11	1.64±0.05	0,35±0,09
	5 BIE	5	4.44±0.02	68.00±1.78	19.15±0.41	2.41±0.14	2.08±0.09	0,68±0,04
p value			0.002	0.034	0.004	0.377	0.003	0.007
SBP 30	0 BIE	5	4.25±0.03	65.02±0.95	17.06±0.23	2.93±0.11	2.07±0.07	0,61±0,02
	5 BIE	5	4.38±0.02	61.50±2.78	14.09±0.58	2.32±0.10	1.98±0.08	0,68±0,03
p value			0.004	0.229	0.001	0.003	0.434	0.132

NH_3-N: ammonia nitrogen, LA: lactic acid, AA: acetic acid, PA: propionic acid, pH: power of hydrogen. a, b, c, d: Means with different superscripts in the same column are significantly different ($p<0.05$).

Table 4. Energy content, IVD, RFV Levels and Fleig Scores of the Silages (%)

SBP		N	IVD		DE, Mkal. kg^{-1} KM	ME, kkal. kg^{-1} KM	NEL, Mkal. kg^{-1} KM	RFV	Fleig Scores	Qualifica-tions class
			DMD	OMD						
SBP 0		10	61,05±1,32b	56,16±1,39b	2,48±0,06b	2,03±0,05b	1,26±0,03b	110.04±3.31b	77.04±2.39	GOOD
SBP 10		10	64,83±1,27a	60,76±1,17a	2,68±0,05a	2,20±0,04a	1,37±0,03a	112.16±2.86a	75.76±2.90	GOOD
SBP 20		10	64,59±1,51a	58,89±1,18a	2,60±0,05a	2,16±0,05a	1,35±0,03a	102.64±2.39c	78.41±1.76	GOOD
SBP 30		10	64,63±0,32a	60,78±0,42a	2,64±0,04a	2,20±0,02a	1,35±0,02a	103.62±3.14bc	78.82±1.21	GOOD
p value			0,000	0,000	0,001	0,000	0,001	0.018	0.129	
BIE										
0 g.ton-1 BIE		20	66,39±0,52	61,43±0,51	2,69±0,03	2,23±0,02	1,38±0,02	107.42±1.84	82.42±0.60	EXCELLENT
5 g.ton-1 BIE		20	60,97±0,72	56,64±0,85	2,50±0,04	2,05±0,03	1,27±0,02	107.05±2.57	72.73±1.00	GOOD
p value			0,000	0,000	0,000	0,000	0,000	0.930	0.000	
SBP x BIE			0,000	0,010	0,005	0,013	0,005	0.000	0.014	
SBP 0	0 BİE	5	64,66±0,47	59,38±0,71	2,62±0,03	2,15±0,03	101.48±2.10	83.20±0.67		EXCELLENT
	5 BİE	5	57,43±1,05	52,13±1,01	2,30±0,04	1,88±0,04	118.60±2.89	70.87±0.87		GOOD
p value			0,000	0,001	0,001	0,001	0,001	0.001	0.000	
SBP 10	0 BİE	5	67,90±0,68	63,04±0,83	2,78±0,04	2,28±0,03	111.92±4.60	82.83±1.18		EXCELLENT
	5 BİE	5	61,00±0,33	57,91±1,49	2,55±0,07	2,09±0,05	112.40±3.95	68.70±2.17		GOOD
p value			0,000	0,016	0,016	0,016	0,016	0.939	0.001	
SBP 20	0 BİE	5	68,32±1,04	62,18±1,14	2,74±0,05	2,29±0,05	104.23±3.41	82.86±1.52		EXCELLENT
	5 BİE	5	60,86±0,57	56,25±0,56	2,48±0,02	2,03±0,02	101.36±3.56	74.86±1.63		GOOD
p value			0,001	0,002	0,002	0,002	0,002	0.587	0.010	
SBP 30	0 BİE	5	64,73±0,54	61,21±0,41	2,62±0,08	2,21±0,01	111.40±2.41	81.11±1.36		EXCELLENT
	5 BİE	5	64,56±0,43	60,35±0,72	2,66±0,03	2,18±0,03	95.84±2.90	75.96±0.93		GOOD
P value			0,805	0,341	0,695	0,341	0,695	0.003	0.021	

RFV: relative feed value, DMD: dry matter digestibility. OMD: organic matter digestibility. DE: digestible energy. ME: metabolic energy. NE_L: net energy lactation a, b, c: Means with different superscripts in the same column are significantly different ($p<0.05$).

between the groups was found to be significant except for Fleig scores. The effect of the BI+E dose was not significant for RFV but was significant for the other parameters ($p<0.05$). In all SBP-supplemented silages examined in the trial, the Fleig scores were determined to be "good". The Fleig scores of the groups that did not include the addition of BI+E were "excellent", whereas the scores of those that included BI+E at 5 $g.ton^{-1}$ were "good". The effect of the SBPxBI+E interaction on the quality of the silages was statistically significant ($p<0.05$).

Discussion

The main problems that need to be solved for sustainable animal farming include meeting the need for high-quality and inexpensive roughage. It is highly important to use alternative roughage that is not only inexpensive but also not used for human consumption to feed ruminants. In this sense, confectionary sunflower could be an alternative roughage source due to these desirable characteristics. Before ensiling, in comparison with the control group, the additives usually lowered the DM and EE levels of the groups and increased their CP, NDF, and ADF values, but they did not significantly affect the OM and CA levels.

The nutrient contents of the HCSC silages are presented in Table 2. The effects of SBP supplementation ratio on all examined nutrient parameters were significant ($p<0.05$). SBP addition increased the OM and CP levels of the silages and reduced their DM, CA, EE, NDF, and ADF values. This result may be attributed to the high OM content of SBP. Considering the increase in the CP and EE levels and decrease in the NDF and ADF levels of the silages based on the ratios of SBP supplementation, this result was directly dependent on the SBP content. The proportional decreases observed in NDF and ADF occurred as a result of the increase in the nitrogen-free extract amounts as a consequence of fermentation caused by the addition of SBP and the decrease in the ratio of structural carbohydrates. Similarly, the effects of BI+E addition on the nutrient contents of the silages were significant, except for those of DM and EE ($p<0.05$). In the silages to which BI+E was added, there were increases in CA, CP, NDF, and ADF and decreases in DM, OM, and EE contents. In a study where SBP silages were prepared using ground wheat and molasses as additives at different ratios (Avcı et al., 2005), the additives increased the CP values and lowered the NDF and ADF values of the silages. The DM, CA, CP, NDF, and ADF values of the silages, as nutrient contents, ranged from 12.55–17.99, 3.55–6.90, 6.92–12.59, 63.06–81.87, and 26.30–63.66, respectively. Compared with the values obtained in this study, these results were lower in terms of DM and CA and higher in terms of CP, NDF, and ADF. In a study on the usability of silages prepared by adding whey powder and urea to sunflower residues as a potential feed source for Mohabadi dairy goats (Gholami-Yangije et al., 2019), it was determined that, in comparison with additive-free silages, additive-containing silages presented higher CP values and lower NDF and ADF values. These values were similar to those obtained in this study. Researchers have also reported that sunflower residue silages could be an acceptable feed source for Mohabadi dairy goats. In a study carried out by Erdoğan and Demirel (2016), the use of additives increased the DM values of the silages of sunflower crops reaped in different vegetation periods and inoculated with different levels of fibrolytic enzymes. However, enzyme supplementation did not have a substantial effect on the nutritional value or properties of the silages. Denek et al. (2004) reported that adding a mixture of urea and ground wheat reduced the NDF and ADF values of silages. In another study where the quality of silages obtained by ensiling sunflower crops with different additives was investigated (Laloğlu, 2015), while the additives increased the CP values of the sunflower silages, the addition of molasses lowered the NDF values of the silages in comparison to those of the groups with the addition of enzymes and LAB; however, the additives did not significantly affect the ADF values.

The fermentation values of silages are among the important criteria used to determine their quality. In this study, the pH values of the silages ranged from 4.25–4.64. These values were close to those reported to be the optimum silage pH values, which are in the range of 3.8–4.2 (Kung & Shaver, 2001). Adding SBP to the silages lowered the pH, NH_3-N concentrations, and NH_3-N/total N ratios of the silages and thus reduced the protein catabolism and buffer capacity values. Adding BI+E to the silages, on the other hand, increased these values. SBP addition also reduced LA and PA values and increased AA values. The addition of BI+E to the silages increased their AA and PA values and lowered their LA levels ($p<0.05$). Moreover, the effects of the SBPxBI+E interaction on the fermentation values of the silages were significant except for PA ($p<0.05$).

In a study where the effects of lactic acid bacteria inoculants on the fermentation and aerobic stability properties of sunflower silages were investigated (Özdüven et al., 2017), it was observed that the LA bacteria inoculants lowered the pH and NH_3-N values of the silages compared with those of the control group, and the homofermentative lactic acid bacteria inoculant improved the fermentation properties of the sunflower silages. These results were different from those obtained in this study. In a similar study, Koç et al. (2009), who determined the fermentation and aerobic stability characteristics of sunflower silages, reported a silage pH value of 3.84 and reported LA and AA concentrations of 1.51% and 1.76%, respectively. These values were lower than those obtained in this study for pH and LA content and higher than those obtained for AA content. The same researchers reported that the addition of a bacterial inoculant to sunflower crops improved the fermentation quality parameters of silages. Özdüven et al. (2009) reported that the pH values of sunflower silages ranged from 3.96–4.22 and that LA concentrations varied between 5.96% and 7.94% in DM. These concentrations increased with the addition of BI+E, and NH_3-N concentrations decreased (65.46 $g.kg^{-1}$ TN) due to the same effect. Similarly, in this study, the addition of BI+E lowered the LA values of the silages, but it increased the pH and NH_3-N values. Homofermentative LA bacterial inoculants that were used during the ensiling of sunflower crops promoted lactic acid production in the silages. As a result, the pH of the silages decreased, their acetic acid and NH_3-N concentrations significantly decreased, and the quality of the silages increased. On the other hand, heterofermentative LA bacterial inoculants increased the ammonia nitrogen and acetic acid contents of the silages and reduced their lactic acid/acetic acid ratio (Tepeli, 2014).

The Fleig score, which is a convenient method for determining the quality of silages, is calculated on the basis of pH and DM ratios, and all factors that affect pH and DM values also affect the Fleig score (Kılıç, 1986). In this study, in all SBP-supplemented silages, the Fleig scores were determined to be “good”, and the Fleig scores of the groups that did not include the addition of BI+E were “excellent”, whereas the scores of those that included BI+E at 5 $g.ton^{-1}$ were “good”. In parallel with an increase in the ratio of SBP used in the silage groups, the Fleig scores increased, and the RFV levels decreased. Similarly, the BI+E that was used in the silages led to a reduction in Fleig scores but did not create a significant change in RFV results. The RFV results of the majority of the silage groups were greater than 100 units, which is accepted as an indicator of good quality (Canbolat et al., 2019). The Fleig scores of silages that were obtained by ensiling SBP with some fruit industry wastes were found to be in the range of 31.27–61.93, and their quality classes were between medium and good (Ülger et al., 2015). These values were lower than the values obtained in this study. In a study performed using the inoculant-free and inoculant-added silages of sunflower, cowpea, sorghum, and soy plants, the addition of the inoculant had a positive effect; the best silage types in terms of feed value among those with inoculant addition were the sunflower and cowpea silages, and among the inoculant-free silages, the cowpea silage had a rating of “excellent” in terms of feed value (Ayaşan & Karakozak, 2012). In a study that examined the silage quality, nutrient contents, and RFV results of no-cob sweet corn silages with urea and molasses addition, an increase in the amount of urea used in the silage groups resulted in a decrease of Fleig scores, physical parameters, and RFV results. Compared to the control group, the silages supplemented with molasses presented higher Fleig scores and RFV results (Yıldız, 2024).

Conclusions

Considering the crude nutrients, fermentation characteristics, IVDs, Fleig scores, and RFV levels of headless confectionary sunflower crop (HCSC) silages prepared by the addition of SBP and BI+E as additives, good- and excellent-quality silages were obtained. It was concluded that the additives contributed to silage quality; thus, it would be more appropriate to use BI+E in addition to a carbohydrate source such as SBP rather than only for HCSC silages, and these silages could be used as alternative roughage sources for feeding ruminants.

Conflict of interest

The authors declare that they have no conflicts of interest.

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