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Forage turnip (*Brassica rapa*) harvested in different phases of vegetative stage and ensiled with the additives of molasses and barley and the effects of additives on silage quality, in vitro digestibility, and energy content

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Abstract: This study was conducted to determine the silage quality, in vitro digestibility and energy content of forage turnip (*Brassica rapa)* ensiled with molasses or ground barley. Forage turnip was harvested at three different stages: the beginning, middle and end of the flowering period, and it was ensiled with no additive (control), 5% molasses or 4% ground barley. In the trial, pH, nutrient contents, ammonia nitrogen (NH_3-N) contents, volatile fatty acid (VFA) contents, Fleig scores, in vitro digestibility and energy content were determined. It was observed that the effect of the vegetative stage on the difference between the groups was significant ($p < 0.05$). Accordingly, with the progression of the vegetative stage, the contents of dry matter (DM), organic matter (OM), ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) showed an increase while a decrease was observed in crude protein (CP). The effects of the additives on the difference between the groups were found to be significant except for the CP parameter ($p < 0.05$). Molasses and barley addition to the silages increased DM, OM and EE contents and reduced the levels of NDF and ADF. With the progression of the vegetative stage, lactic acid (LA) and acetic acid (AA) values decreased while pH values and Fleig scores increased. The effects of additives were found to be insignificant for all parameters except for AA and Fleig scores. As the vegetative stage progressed, the dry matter digestibility (DMD), organic matter digestibility (OMD), digestible energy (DE), metabolic energy (ME) and net energy for lactation (NE_L) values of the silages decreased significantly ($p < 0.05$). The addition of molasses or barley, compared to the control, resulted in a significant increase in the levels of DMD, OMD, DE, ME, and NE_L ($p < 0.05$). In conclusion, in parallel with the progression of the vegetative stage, the DMD, OMD, DE, ME, and NE_L values of the silages decreased, increasing with the addition of the additives, and the obtained silages were of high-quality as alternative quality roughage in ruminant feeding.

Key words: Forage turnip (*Brassica rapa*), silage, digestibility, energy content

1. Introduction

Today, it is known that the shortage of good-quality roughage supply still continues in the livestock industry, and the production of quality silage is insufficient. To meet the roughage demand in Turkey, the production of silage feed should be expanded. Thus, it will be possible to produce more durable silages of higher quality, containing nutrients close to the starting material, and to provide these for animals. Silage feeds should be of high quality, yet low cost and economical. By using high-quality and water-rich silo feeds instead of hay and straw, which are the most commonly used roughage sources for ruminants, an increase in the yield of animal products and a decrease in metabolic diseases and feed costs would be achieved due to the reduction of concentrated feed use [1].

In Turkey, corn crops are generally used as plants for silage feed, and the utilization level of other products suitable for ensiling is quite low. One of the most important plants in the agriculture of Turkey because of its many beneficial aspects is forage turnip among the aforementioned plants. Forage turnip (grass-type forage turnip, *Brassica rapa L.*) is commonly grown in Anatolia, and it is possibly the first *Brassica* cultivar (cultivated variety). *Brassica* species are among the alternative forage plants commonly produced and used to supply forage requirements during limited forage production in different regions of the world. The leaves of forage turnip (*Brassica rapa),* rape (*Brassica napus ssp. oleifera*) and cabbage (*Brassica oleracea)* have gained importance among the plant species used as forage plant sources. Forage turnip is an annual and winter fodder plant. For high yield in forage turnip, it is recommended to plant it at the end of October. It is a highly productive fodder plant with large leaves and a height of up to 2.5 m. It has an important role among

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the fodder crops that can be used by cattle producers who are engaged in meat and dairy cattle breeding to reduce their daily feed costs. Forage turnip is a forage plant that provides a lot of green grass in a short period of time and that animals love to be fed with. Its rate of digestion is quite high. Aboveground parts normally contain 20% to 25% crude protein, 65% to 80% in vitro digestible dry matter (IVDDM), about 20% neutral detergent fiber (NDF), and about 23% acid detergent fiber (ADF). After planting under convenient conditions, it reaches harvest maturity in a short period of time. During this maturity stage, grazing can be done by releasing animals directly to the field, or the plant can be used as freshly cut fodder and silage. Since forage turnip reaches harvest maturity early, it also allows second crop cultivation [2–6].[1 2 3]

Forage turnip can be ensiled after the withering process is applied or by mixing it with other fodder crops. It can be ensiled without using any additives. The most suitable harvest period for silage is the full flowering stage. The amount that would be served to dairy cattle should be between 5 and 7.5 kg per animal. Giving it to cattle shortly before milking may lead to deterioration in the taste and odor of the milk [7, 8].

The purpose of this study was to determine the most suitable harvest period of forage turnip and the silage quality, in vitro digestibility and energy content of its silages prepared by mixing different amounts of additives.

2. Materials and methods

2.1. Materials

The forage turnips used in this study were obtained from Van Yüzüncü Yıl University Research and Application Farmland, while the ground barley and molasses were obtained from a regular market in Van.

2.2. Methods

Making silage: The study was carried out according to the 3 × 3 factorial trial design. Forage turnip plants were harvested in three different vegetation periods, and it was used without additives (control), with 5% molasses or with 4% ground barley by mixing on a weight basis, and a total of 45 silage samples were packed into 1-L glass jars as shown in Table 1. The lids of the glass jars were pierced, and the silo water was drained for 48 h by turning the jars upside down. The jars were opened after 70 days of incubation.

Chemical analysis: Immediately after the silage was opened, the pH values of the silage liquids were measured with a digital pH meter [9]. All samples were dried at 65 °C for 48 h 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 [10], whereas ADF and NDF analyses were conducted according to the method suggested by Goering and van Soest [11]. The distillation method was used in the calculation of the NH_3-N concentrations of the silage fluids [12]. The acetic acid (AA), propionic acid (PA), butyric acid (BA) and lactic acid (LA) levels of the silage liquids were identified in an HPLC device with the Agilent Hi-Plex organic acid column [13].

Determination of Fleig scores, in vitro digestibility, and energy content of silages: The Fleig scores of the silages were calculated according to the method reported by Kılıç [14] with the equation of 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 [15]:

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

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

In determining the energy contents of the silages, formulas reported by NRC (1989) [16] and Ishler et al. [17] were used.

DE, digestible energy, Mcal/kg DM [17]

DE = TDN% (OMD) × 0.04409

ME, metabolic energy, kcal/kg DM [17]

ME = DE × 0.082

NEL, net energy lactation, Mcal/kg DM [16]

NE_L = (TDN% (OMD) × 0.0245) – 0.12

Statistical analysis: Analysis of variance (ANOVA) was used for the statistical analysis of the data obtained in the study, and Duncan's multiple comparison test was used to identify the sources of the differences between groups [18]. For this purpose, the SPSS software was used [19].

3. Results

In this study, the nutrient contents, silage quality, in vitro digestibility and energy contents of silages of forage turnip prepared at different vegetative stages with different additives were investigated. The nutrient contents of the

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forage turnip before ensiling are given in Table 2. As seen in Table 2, the difference between the DM, OM, CA, and EE values of the groups before ensiling was significant. The CP, NDF, and ADF values of the groups were similar.

According to the results of examination on the nutrient contents of the silages, the effect of the vegetative stage on the difference between the groups was significant. Again, the effects of the additives used in the experiment on the difference between the groups in terms of nutrient content were significant, except for the CP parameter. Moreover, the effects of the interaction of period × additive on the nutrient contents of these silages was determined to be significant, except for the CP, NDF and ADF parameters (Table 3).

One of the important criteria in determining the quality of silages is the fermentation values of silages. In this study, it was found that the effect of the vegetative stages on the difference between the groups in terms of the fermentation values of the silages was significant, except for the PA parameter. The effects of the additives on the difference between the groups in terms of NH_3-N, LA, PA and pH were insignificant, yet these effects were significant for AA and Fleig scores. The degree of quality for the silages that were examined in this study based on their Fleig scores was "Excellent". It was also determined that the period × additive interaction of the fermentation values of these silages was significantly effective except for the LA, AA and PA parameters (Table 4).

As seen in Table 5, in which the in vitro DM and OM digestibility and energy values of the forage turnip silages are given, the effects of the vegetative stage and additives on the difference between the groups was significant. The effects of these variables on the in vitro DM and OM digestibility of the silages and the effects of the period × additive interaction on the energy values were found to be insignificant.

4. Discussion

One of the important problems to be solved in the development of animal husbandry in Turkey is to supply the demand for quality and inexpensive roughage regularly. In ruminant feeding, it is very important to use alternative roughages of good quality, which are both inexpensive and not used for human consumption. From this aspect, forage turnip stands out due to its superior properties. In this study, the nutrient content, silage quality, in vitro

Table 1. Trial layout of the study.

Vegetation stage	Additive type	Recurence
Beginning of the flowering	Control	5
Beginning of the flowering	Molasses, 5%	5
Beginning of the flowering	Ground barley, 4%	5
Middle of the flowering	Control	5
Middle of the flowering	Molasses, 5%	5
Middle of the flowering	Ground barley, 4%	5
End of the flowering	Control	5
End of the flowering	Molasses, 5%	5
End of the flowering	Ground barley, 4%	5

Table 2. Nutrient content (DM, %) of the forage turnip before ensiling.

Groups	n	DM, %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
Beginning of the flowering	3	17.21 ± 0.79c	91.40 ± 0.63b	8.60 ± 0.63a	7.73 ± 1.02	1.57 ± 0.20b	43.01 ± 4.28	29.79 ± 3.29
Middle of the flowering	3	21.31 ± 0.81b	92.42 ± 0.36ab	7.58 ± 0.36ab	8.67 ± 0.42	2.37 ± 0.23a	48.87 ± 2.36	36.90 ± 1.10
End of the flowering	3	24.27 ± 0.73a	94.00 ± 0.51a	6.00 ± 0.51b	7.63 ± 0.63	2.71 ± 0.12a	51.43 ± 2.67	37.37 ± 1.94
p-value		* *	* *	* *	-	*	-	-

DM: dry matter, OM: organic matter, CA: crude ash, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber. *: ($p < 0.05$); * *: ($p < 0.01$).
a, b, c: Means with different superscripts in the same column are significantly different ($p < 0.05$).

Table 3. Nutrient content (DM, %) of the forage turnip silages.

Period		n	DM, %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
Beginning of the flowering		15	17.96 ± 0.33c	92.84 ± 0.19b	7.16 ± 0.19b	9.46 ± 0.19a	1.99 ± 0.12b	45.58 ± 0.84b	33.91 ± 0.80b
Middle of the flowering		15	20.12 ± 0.44b	92.29 ± 0.19c	7.71 ± 0.19a	8.57 ± 0.11b	3.21 ± 0.40a	49.05 ± 0.77a	36.09 ± 0.82ab
End of the flowering		15	24.05 ± 0.40a	93.39 ± 0.14a	6.67 ± 0.14b	8.08 ± 0.10c	3.82 ± 0.42a	49.76 ± 0.67a	37.13 ± 0.71a
p-value			* * *	* * *	* * *	* * *	* * *	* * *	*
Additive									
Control		15	18.99 ± 0.65b	92.96 ± 0.16b	7.04 ± 0.16b	8.57 ± 0.16	1.90 ± 0.12b	50.97 ± 0.56a	38.75 ± 0.64a
Molasses		15	21.93 ± 0.82a	92.06 ± 0.17c	7.94 ± 0.17a	8.73 ± 0.19	3.79 ± 0.39a	46.82 ± 0.75b	34.06 ± 0.54b
Ground barley		15	21.69 ± 0.69a	93.44 ± 0.13a	6.62 ± 0.13b	8.71 ± 0.26	3.24 ± 0.40a	46.54 ± 0.81b	34.18 ± 0.63b
p-value			* *	* * *	* * *	-	* * *	* * *	* * *
Period × additive			* *	*	*	-	* * *	-	-
Beginning of the flowering	Control	5	16.45 ± 0.13b	92.68 ± 0.10b	7.32 ± 0.10b	9.14 ± 0.15	1.93 ± 0.27	49.00 ± 0.80a	37.11 ± 0.84a
	Molasses	5	18.49 ± 0.30a	92.04 ± 0.16c	7.96 ± 0.16a	9.30 ± 0.47	2.21 ± 0.10	43.67 ± 0.83b	32.19 ± 0.85b
	Ground barley	5	19.04 ± 0.15a	93.64 ± 0.13a	6.36 ± 0.13c	10.03 ± 0.23	1.87 ± 0.20	43.70 ± 0.88b	32.08 ± 0.82b
p-value			* * *	* * *	* * *	-	-	-	* *
Middle of the flowering	Control	5	18.35 ± 0.21b	92.52 ± 0.18a	7.48 ± 0.18b	8.65 ± 024	1.74 ± 0.18	51.28 ± 0.68	38.72 ± 1.28a
	Molasses	5	21.02 ± 0.31a	91.42 ± 0.16b	8.58 ± 0.16a	8.70 ± 0.16	4.07 ± 0.74	47.51 ± 0.65	33.68 ± 0.59b
	Ground barley	5	21.58 ± 0.34a	92.92 ± 0.20a	7.08 ± 0.20b	8.37 ± 0.21	3.23 ± 0.16	48.06 ± 1.65	35.39 ± 1.14ab
p-value			* * *	* * *	* * *	-	-	-	*
End of the flowering	Control	5	22.17 ± 0.39c	93.69 ± 0.14a	6.31 ± 0.14b	7.94 ± 0.07	1.96 ± 0.14b	52.63 ± 0.70a	40.43 ± 0.72a
	Molasses	5	25.59 ± 0.12a	92.72 ± 0.02b	7.28 ± 0.02a	8.30 ± 0.25	4.78 ± 0.25a	48.79 ± 0.81b	35.87 ± 0.36b
	Ground barley	5	24.40 ± 0.20b	93.77 ± 0.17a	6.36 ± 0.14b	8.01 ± 0.14	4.96 ± 0.50a	47.87 ± 0.61b	35.08 ± 0.71b
p-value			* * *	* * *	* * *	* * *	* * *	* * *	* * *

DM: dry matter, OM: organic matter, CA: crude ash, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber. *: ($p < 0.05$); * *: ($p < 0.01$); * * *: ($p < 0.001$).
a, b, c: Means with different superscripts in the same column are significantly different ($p < 0.05$).

digestibility and energy content of silages of forage turnip prepared at different vegetative stages with different additives were investigated.

The nutrient contents of the forage turnip before ensiling are given in Table 2. As seen in Table 2, the difference between the DM, OM, CA, and EE values of the groups before ensiling was found to be significant. There was no statistically significant difference between the groups in terms of their CP, NDF, and ADF values. It was observed that the DM and OM values increased depending on the progression of the vegetation stage ($p < 0.01$). While the CA content decreased with the progression of vegetation, the EE content showed an increase. The CP, NDF, and ADF levels at different vegetative stages of forage turnip before ensiling were found to be similar. In their silage study on the forage turnip plant (*Brassica rapa L.*), Daş [20] found that before ensiling, the DM, CA, CP, ADF, and NDF contents of the plant were found 18.06%, 8.81%, 10.35%, 38.71%, and 42.14%, respectively. These values were similar to the DM and CA contents obtained in this study, while they were higher in comparison to the CP, ADF, and NDF contents in this study. In another study, the ADF content of leaves of green fodder turnip was determined as 18.34%–19.74%, and their NDF content was found to be in the range of 21.84%–23.50% [21]. These values were lower than the values obtained in this study. In a study examining the yield characteristics of varieties of some fodder turnips (*Brassica rapa L.*), the protein and ash ratios of plant leaves were between in the ranges of 12.53%–21.56% and 11.15%–10.28%, respectively [22].

In this experiment, the forage turnip plant was harvested at three different vegetative stages and ensiled with molasses or ground barley on a weight basis. According to the analysis results on the nutrient content of the forage turnip silages (Table 3), the effect of the vegetative stage on the difference between the groups was significant. As the vegetative stage progressed, the DM, OM, EE, NDF, and ADF contents increased, while the CP level decreased. The

Table 4. Fermentation quality and Fleig scores of the forage turnip silages.

Period		n	NH_3-N mg/dL	LA, %	AA, %	PA, %	pH	Fleig scores	Qualifications class
Beginning of the flowering		15	73.89 ± 1.99b	5.40 ± 0.20a	0.48 ± 0.03a	0.04 ± 0.01	3.72 ± 0.03b	92.12 ± 1.93b	Excellent
Middle of the flowering		15	83.56 ± 3.08a	3.85 ± 0.16b	0.34 ± 0.03b	0.04 ± 0.01	3.71 ± 0.02b	97.42 ± 0.99a	Excellent
End of the flowering		15	66.07 ± 1.59c	2.95 ± 0.10c	0.25 ± 0.02c	0.28 ± 0.14	3.83 ± 0.01a	99.90 ± 0.79a	Excellent
p-value			* * *	* * *	* * *	-	* * *	* * *	
Additive									
Control		15	72.01 ± 1.25	4.30 ± 0.30	0.43 ± 0.04a	0.24 ± 0.14	3.77 ± 0.03	92.58 ± 1.84b	Excellent
Molasses		15	75.74 ± 3.89	3.82 ± 0.29	0.27 ± 0.04b	0.11 ± 0.08	3.76 ± 0.02	98.29 ± 1.29a	Excellent
Ground barley		15	74.87 ± 3.20	4.01 ± 0.41	0.35 ± 0.03ab	0.03 ± 0.02	3.73 ± 0.03	98.66 ± 0.95a	Excellent
p-value			-	-	*	-	-	* *	
Period × additive			* * *	-	-	-	* * *	* * *	
Beginning of the flowering	Control	5	75.35 ± 1.03a	5.39 ± 0.35	0.57 ± 0.06	0.04 ± 0.03	3.84 ± 0.03a	84.15 ± 1.37c	Excellent
	Molasses	5	65.07 ± 1.66b	4.94 ± 0.40	0.44 ± 0.05	0.03 ± 0.02	3.72 ± 0.04b	93.08 ± 2.08b	Excellent
	Ground barley	5	78.01 ± 2.87a	5.75 ± 0.28	0.42 ± 0.02	0.04 ± 0.01	3.59 ± 0.01c	99.32 ± 0.57a	Excellent
p-value			*	-	-	-	* * *	* * *	
Middle of the flowering	Control	5	71.31 ± 2.05b	4.22 ± 0.32	0.40 ± 0.05	0.05 ± 0.02	3.67 ± 0.05	97.18 ± 0.54	Excellent
	Molasses	5	91.11 ± 1.50a	3.68 ± 0.13	0.25 ± 0.01	0.05 ± 0.02	3.73 ± 0.01	97.76 ± 1.03	Excellent
	Ground barley	5	84.88 ± 5.05a	3.64 ± 0.31	0.37 ± 0.04	0.03 ± 0.01	3.72 ± 0.04	97.26 ± 2.77	Excellent
p-value			*	-	-	-	-	-	
End of the flowering	Control	5	69.19 ± 2.15	3.29 ± 0.14a	0.32 ± 0.02a	0.57 ± 0.33	3.80 ± 0.02	97.33 ± 1.14b	Excellent
	Molasses	5	68.38 ± 3.19	2.90 ± 0.09b	0.18 ± 0.01c	0.25 ± 0.24	3.83 ± 0.01	102.98 ± 0.67a	Excellent
	Ground barley	5	61.73 ± 1.75	2.66 ± 0.07b	0.25 ± 0.01b	0.02 ± 0.01	3.86 ± 0.02	99.40 ± 0.85b	Excellent
p-value			-	* *	* * *	-	-	* *	

NH_3-N: ammonia nitrogen, LA: lactic acid, AA: acetic acid, PA: propionic acid, pH: power of hydrogen.
a, b, c: Means with different superscripts in the same column are significantly different ($p < 0.05$).
*: ($p < 0.05$); * *: ($p < 0.01$); * * *: ($p < 0.001$)

effect of the additives on the difference between the groups was found to be significant except for the CP parameter. While molasses or barley addition to the silages increased their DM, OM, and EE contents, it resulted in decreases in the NDF and ADF levels of the silages. The decrease in the NDF and ADF levels can be explained by the low NDF and ADF levels of molasses and barley used as additives. It was also determined that the effects of the period × additive interaction on the nutrient contents of these silages were significant regarding the parameters of DM, OM, CA, and EE. Silage quality and in vitro digestibility were determined in silages produced using 5% wheat additive for three different subspecies of the genus *Brassica* (Forage turnip (*Brassica rapa*), black mustard (*Brassica nigra*) and canola (*Brassica napus L.*)) [3]. In the study, the DM, CA, EE, CP, NDF, and ADF contents of black mustard for no additives and wheat-added silages were 23.43%–24.75%, 11.38%–10.79%, 3.36%–2.24%, 14.60%–12.06%, 48.25%–49.36% and 41.10%–43.74%, respectively; these contents for forage turnip were consecutively 22.11%–23.94%, 10.12%–9.21%, 1.90%–1.25%, 7.76%–7.30%, 61.16%–58.37% and 53.05%–50.50%, and for canola, they were successively 24.32%–27.91%, 11.10%–9.98%, 3.34%–2.68%, 10.32%–10.89%, 50.61%–46.01%, and 44.78%–39.48%. Regarding the values of forage turnip silage in the study cited above, the values of DM, CA, NDF, and ADF in their study were higher in comparison to those in this study, whereas their CP values were lower, and their EE values were similar. In the study conducted by Daş [20], where the nutritional values of silages prepared by adding wheat straw and molasses at different levels to forage turnip were examined, the DM, CA, CP, ADF, and NDF values in silage in which 3% molasses was added were determined as 20.20%, 8.62%, 10.68%, 44.06%, and 46.50%, respectively. When the results found by Daş (20) were compared with the values of forage turnip silages

Table 5. Energy content and in vitro digestibility of silages of forage turnip (DM, %).

Period		n	DMD, %	OMD, %	DE, Mcal/kg DM	ME, kcal/kg DM	NE_L, Mcal/kg DM
Beginning of the flowering		15	62.65 ± 1.03a	66.38 ± 1.23a	2.93 ± 0.05a	2.40 ± 0.04a	1.51 ± 0.03a
Middle of the flowering		15	57.41 ± 1.10b	62.11 ± 1.53b	2.74 ± 0.07b	2.25 ± 0.06b	1.40 ± 0.04b
End of the flowering		15	53.82 ± 1.31c	55.72 ± 1.19c	2.46 ± 0.05c	2.01 ± 0.04c	1.25 ± 0.03c
p-value			* * *	* * *	* * *	* * *	* * *
Additive							
Control		15	53.77 ± 1.45b	56.81 ± 1.69b	2.54 ± 0.08b	2.09 ± 0.06b	1.29 ± 0.04b
Molasses		15	61.74 ± 1.21a	62.04 ± 1.72a	2.74 ± 0.08a	2.24 ± 0.06a	1.40 ± 0.04ab
Ground barley		15	58.72 ± 1.08a	64.53 ± 1.62a	2.84 ± 0.07a	2.33 ± 0.06a	1.46 ± 0.04a
p-value			* * *	* *	*	*	*
Period × additive			-	-	-	-	-
Beginning of the flowering	Control	5	58.94 ± 0.89b	61.68 ± 0.36b	2.77 ± 0.06b	2.28 ± 0.05b	1.42 ± 0.03b
	Molasses	5	66.05 ± 1.34a	68.25 ± 0.59a	3.01 ± 0.03a	2.47 ± 0.02a	1.55 ± 0.01a
	Ground barley	5	62.96 ± 0.76a	69.21 ± 0.86a	3.05 ± 0.04a	2.50 ± 0.03a	1.58 ± 0.02a
p-value			* *	* * *	* *	* *	* *
Middle of the flowering	Control	5	54.10 ± 1.49b	59.29 ± 1.74	2.61 ± 0.08	2.14 ± 0.06	1.33 ± 0.04
	Molasses	5	61.06 ± 0.39a	61.16 ± 3.63	2.70 ± 0.16	2.21 ± 0.13	1.38 ± 0.09
	Ground barley	5	57.97 ± 1.28ab	65.87 ± 0.52	2.90 ± 0.02	2.38 ± 0.02	1.49 ± 0.01
p-value			*	-	-	-	-
End of the flowering	Control	5	48.27 ± 1.09c	51.31 ± 1.48b	2.26 ± 0.07b	1.86 ± 0.05b	1.14 ± 0.04b
	Molasses	5	57.94 ± 0.70a	58.04 ± 0.44a	2.56 ± 0.02a	2.10 ± 0.02a	1.30 ± 0.01a
	Ground barley	5	55.24 ± 0.67b	58.51 ± 0.75a	2.58 ± 0.03a	2.12 ± 0.03a	1.31 ± 0.02a
p-value			* * *	* *	* *	* *	* *

DMD: dry matter digestibility, OMD: organic matter digestibility, DE: digestible energy, ME: metabolic energy, NE: net energy lactation.
*: ($p < 0.05$); * *: ($p < 0.01$); * * *: ($p < 0.001$).
a, b, c: Means with different superscripts in the same column are significantly different ($p < 0.05$).

obtained in the midflowering period with 5% molasses added in this study, it was seen that DM, ADF, and NDF values were low, CP values were high and CA values were similar. In another study [23], DM, CA, CP, EE, NDF, and ADF values in forage turnip that was ensiled without additives were determined as 23.18%, 9.65%, 12.53%, 2.92%, 41.05%, and 27.62%, respectively. These values were higher than the control silage values in our study in terms of the DM, CA, CP, and EE values, while their NDF and ADF values were lower. Balakhial et al. [24] found the contents of DM, OM, CP, EE, NDF, and ADF as 17.82%–18.79%, 88.00%–88.00%, 15.68%–15.64%, 6.00%–4.33%, 52.33%–48.66% and 32.33%–32.33%, respectively, in silages of canola without addition and with the addition of 4% molasses among samples to which they added urea and molasses at different proportions. These values were higher than those in our study in terms of CP, EE, and NDF, while the DM, OM, and ADF values they reported were found to be relatively lower.

As seen in Table 4, in which silage fermentation values are given, it was found that the effect of the vegetative stage on the difference between the groups was significant, except for the PA parameter. With the progression of the vegetative stage, the LA and AA values of the silage decreased while the pH and Fleig score values increased. Nevertheless, all pH values were found in the optimum range for all silages. The highest silage NH_3-N values among the groups were obtained for the samples harvested at the midflowering stage, followed by the early flowering and the late flowering stages, respectively. The effects of the additives on the fermentation parameters were found to be insignificant for the NH_3-N, LA, PA and pH parameters but significant for the AA values and Fleig scores. While molasses reduced the AA levels of the silages, both molasses and barley additives increased the Fleig scores of the silages. Regardless, the quality degree of all silages examined in the experiment was determined as “Excellent”. Additionally, it was determined that the effect of the period × additive interaction was significant in terms of the NH_3-N values, pH values and Fleig scores (Table 4). Kılıç and Erişek [3] investigated the effect of wheat addition on the quality of silages obtained with some *Brassica* subspecies (mustard, forage turnip and canola) and the effects of additive use on IVTD (in vitro true digestibility) values. The LA levels in the no additive and 5% wheat-added mustard, forage turnip and canola silages were, 1.83% and 2.11, 1.16% and 4.01 and 2.61% and 2.76, respectively. They reported the AA levels as 1.97% and 3.15, 2.22 and 1.87% and 2.27 and 2.11%, the pH values as 4.98 and 4.85, 5.05 and 5.03 and 4.93 and 4.56, and the Fleig scores as 37.65 and 45.30, 32.11 and 36.89 and 41.65 and 63.32, following the same order. The pH and AA values obtained in their study were higher than the values obtained in this study, while their LA values and Fleig scores were lower than ours. In the study conducted by Daş [20] in silages prepared by adding wheat straw and molasses at different proportions to forage turnip, the values in regard to pH, NH_3-N, LA, AA, and PA for the control group and the group containing 3% molasses were found as 4.55 and 4.22, 10.32 and 11.65%, 3.69 and 6.43, 3.18% and 3.88 and 0.05 and 0.06%, respectively. The pH, AA, and PA values obtained in the study conducted by Daş [20] were higher than the values obtained in our study, their NH_3-N values were lower than those in our study, and their LA values were similar to ours. In the study conducted by Özkan [23], the values of pH, NH_3-N, LA, AA, and Fleig scores, which are the fermentation values regarding forage turnip silage, were determined as 4.20, 74.60, 5.72, 2.91% and 83.36%, respectively. The pH, NH_3-N, LA, and AA values determined by Özkan [23] were higher than the values obtained in our study, whereas their Fleig scores were lower. In another study [24], the pH values of canola silage without additive and 4% molasses-added canola silage were found to be 4.78 and 4.70, respectively, and NH_3-N values were determined respectively as 21.90 and 18.80. These values were higher than the pH values obtained in our study, but the NH_3-N values of theirs were lower.

The effects of the vegetative stage and additives were found to be significant in regard to the in vitro DM and OM digestibility and energy content of the forage turnip silages in our study. With the progression of the vegetative stage, the DMD and OMD values of the silages decreased. This effect likewise influenced the DE, ME and NE_L levels of the silages. Again, the addition of molasses or barley to the silages, compared to the control group, resulted in an increase in the levels of DMD, OMD, DE, ME, and NE_L. The variations in the in vitro digestibility of these silages based on the period × additive interactions of their energy content were found to be insignificant (Table 5). In a study investigating the effects of additives on the quality and IVD of silages obtained from some plants (mustard, forage turnip and canola) belonging to the genus *Brassica* [3], the IVD values of the silages for mustard, forage turnip and canola without additives (control) and with the addition of 5% wheat were reported as 66.84 and 71.63%, 54.89 and 55.37% and 67.74% and 65.80%, respectively. These results were found to be higher for mustard and canola than the values obtained in our study, and they were close to the one for forage turnip. In a study, the IVOMD and ME values of silages prepared by adding different proportions of wheat straw and molasses to forage turnip were reported as 50.18% and 54.12 in the control groups and 7.69 and 8.32 MJ/kg DM in the 3% molasses groups [20]. The IVOMD and ME values found by the researcher were lower than the values obtained in our study.

According to the results obtained in our study, high-quality silages were obtained by ensiling forage turnip by adding 5% molasses or 4% ground barley. In parallel with the progression of the vegetation stage, the DMD, OMD, DE, ME, and NE_L values of the silages decreased, while it was concluded that all silages were of good quality and could be used as an alternative source of quality roughage in the feeding of ruminants.

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