Journal of Animal & Plant Sciences, 33(4): 2023, Page: 855-863
ISSN (print): 1018-7081; ISSN (online): 2309-8694
https://doi.org/10.36899/JAPS.2023.4.0678

EFFECTS OF ENSILING FORAGE TURNIP (*BRASSICA RAPA*) PLANT HARVESTED IN DIFFERENT VEGETATION PERIODS WITH TRITICALE (*X TRITICOSECALE WITTMACK*) FORAGE AT DIFFERENT RATIOS ON SILAGE QUALITY, *IN VITRO* DIGESTIBILITY AND ENERGY CONTENT

S. Yıldız[1*], S. Deniz[2], F. Özkan[2] and Ç. Kale[2]

[1]Van Yüzüncü Yıl University, Gevaş Vocational School, Veterinary Department, Van/ Türkiye
[2] Van Yüzüncü Yıl University, Veterinary Faculty, Animal Nutrition and Nutritional Diseases, Van/ Türkiye
* Corresponding Author's mail:syildiz@yyu.edu.tr

ABSTRACT

This study determined silage quality, *in vitro* digestibility and energy contents in forage turnip (*Brassica rapa L.*) harvested in three different vegetation periods, and it was used without (control) or with 10, 20, 30, 40% triticale (*X Triticosecale Wittmack*). As the vegetation period progressed, the dry matter (DM), organic matter (OM), neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents increased, and the crude ash (CA), crude protein (CP) and ether extract (EE) contents decreased ($p<0.05$). The effects of the triticale ratio on the parameters between the groups were significant ($p<0.05$) except for ADF. As this ratio increased, the DM, CA and NDF contents of the silages increased, their OM levels decreased, and there was no change in CP, EE and ADF. As the vegetation period progressed, the lactic acid (LA) and acetic acid (AA) contents of the silages decreased, and their Fleig scores increased ($p<0.05$). The effects of triticale ratio on the parameters were significant except for propionic acid (PA) ($p<0.05$). As the vegetation period progressed, the dry matter digestibility (DMD), organic matter digestibility (OMD) and energy values of the silages decreased ($p<0.05$). In comparison to the control, the highest DMD, OMD and energy levels were found with triticale added at 20%. If forage turnip is ensiled with triticale forage at ratios of 10% to 30%, the obtained silages are quality silages, and can be used as an alternative, quality source of roughage in the ruminants feeding.

Keywords: Digestibility, Energy content, Forage turnip, Silage, Triticale

Published first online April 15, 2023 Published final August 04, 2023

INTRODUCTION

Silages are preferable forages as a source of roughage that stays fresh for a long time, has low loss rates during storage, is not affected by unfavorable weather conditions and secures feeding for winter conditions. They are also quality sources of roughage with their advantages such as higher nutrient contents compared to fodder, lower losses in the field, variable harvesting times, and the possibility of the effective use of labor. While maize is generally used as a forage crop for ensiling in Turkey and other countries, high amounts of water and a certain temperature are needed to produce maize. For this reason, the utilization rate of other plants that are suitable for ensiling remains very low (Karadağoğlu and Özdüven, 2019; Yıldız *et al.,* 2019; Yıldız, 2019).

One of the plants that are suitable for ensiling and important due to their multiple benefits in animal nutrition is field mustard. Forage turnip (feed turnip; *Brassica rapa L.*) commonly cultivated in Anatolia, and it is probably the first *Brassica* species that has been bred. *Brassica* species are among alternative forage crops that are commonly produced and used around the world to meet roughage needs. Forage turnip is an annual winter forage crop. In order to achieve a high yield in forage turnip, it is recommended to sow at the end of October. Forage turnip is a high-yield forage crop that is also known as turnip rape and feed turnip, is suitable to be cultivated without irrigation, can produce 6-10 tons of yield per decare, is equivalent to alfalfa with its contents of 18-22% protein, 65-80% digestible dry matter, approximately 20% NDF and 23% ADF, and has broad leaves and a height of up to 2.5 m. Its silage is scentless and fondly consumed by animals. Its important advantages include the fact that it requires little maintenance and labor, it allows growing after crops as its harvesting period is short, it is winter-resistant and soil-friendly, and it increases milk yield and quality (Undersander *et al.,* 1991; Kilic, 2009; Tiryakioglu and Turk, 2012; Dogan Das and Denek, 2021; Anonymous, 2022a; Anonymous, 2022b).

In the solution of problems in roughage supply, triticale (*X Triticosecale Wittmack*) (especially pasture-type triticale with 2n=56 chromosomes) is a plant that is newly developing, suitable for intercropping with other plants, which can provide advantages thanks to its resistance to unfavorable soil and climate conditions and has a greater height and more abundant green parts, it produces higher yields in sowing with the purpose of ensiling or fodder. Quality silage production with triticale can be achieved most successfully by harvesting in the milk stage. In some cases, its silage yield is even higher than those of wheat, rye and barley (Kavut *et al.,* 2012; Harmanşah, 2018; Karadağoğlu and Özdüven, 2019).

The current study was conducted in order to determine the silage fermentation properties, nutrient contents, *in vitro* dry matter and organic matter digestibility and energy contents in silages obtained by mixing different ratios of triticale forage into forage turnip harvested in three different vegetation periods as the beginning of flowering, during flowering and beginning of the capsulation.

MATERIALS AND METHODS

The forage turnips and triticale used in this study were obtained from Van Yüzüncü Yıl University Research and Application Farmland.

Ensilage: The study was carried out according to the 3x5 factorial trial design. Forage turnip (FT) plants were harvested in three different vegetation periods, and it was used without (control) or, with 10, 20, 30, 40% triticale (T) by mixing on a weight basis, and a total of 75 silage samples were packed into one liter glass jars as shown in Table 1. The lids of the glass jars were pierced, and the silo water was drained for 48 hours by turning the jars upside down (Karadağoğlu and Özdüven, 2019; Yıldız *et al.,* 2022a; 2022b). At the end of this period, the punctured jar lids were closed with duct tape. The jars were opened after 70 days of incubation.

Table 1: Trial layout

VEGETATION STAGE	MIXTURE TYPE	RECURRENCE
Beginning of the flowering	100% FT+0% T (Control)	5
Beginning of the flowering	90% FT +10% T	5
Beginning of the flowering	80 %FT +20% T	5
Beginning of the flowering	70 %FT +30% T	5
Beginning of the flowering	60% FT +40% T	5
Middle of the flowering	100% FT+0% T (Control)	5
Middle of the flowering	90% FT +10% T	5
Middle of the flowering	80 %FT +20% T	5
Middle of the flowering	70 %FT +30% T	5
Middle of the flowering	60% FT +40% T	5
Beginning of the capsulation	100% FT+0% T (Control)	5
Beginning of the capsulation	90% FT +10% T	5
Beginning of the capsulation	80 %FT +20% T	5
Beginning of the capsulation	70 %FT +30% T	5
Beginning of the capsulation	60% FT +40% T	5

FT: Forage turnip **T:** Triticale.

Chemical Analysis: Immediately after the silage jars were opened, the pH values of the silage liquids were measured with a digital pH meter (Polan *et al,.* 1968). 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 method suggested by Goering and Van Soest (1970). The distillation method was used in the calculation of the NH_3-N concentrations of the silage fluids (Markham, 1942). The acetic, (AA), propionic, (PA), butyric, (BA) and lactic acids (LA) levels from the silage liquids were identified using the High Performance Liquid Chromatography (HPLC) device with the Agilent Hi-Plex organic acid column (Suzuki and Lund, 1980).

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 (1986) with the equation:

Fleig Score=220+(2×%DM-15) -40×pH.

The in-vitro DMD and OMD of the silage samples were determined using an ANKOM DAISY II INCUBATOR (ANKOM Technology 2052 O'Neil Road, Macedon NY 14502) device following formula (Ankom, 2002):

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) and Ishler *et al.* (2000) were used.

DE, digestible energy, Mcal/kg DM, (Ishler *et al.,* 2000)

DE = TDN% × 0.04409

ME, metabolic energy, kcal/kg DM, (Ishler *et al.,* 2000)

ME = DE × 0.82

NE_L, net energy lactation, Mcal/kg DM, (NRC, 1989)

NE_L = (TDN% × 0.0245) – 0.12

Statistical Analysis: 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 multiple comparison test was used to determine the significant differences between the groups (Steel and Torrie, 1980). The significance levels of the results obtained were evaluated at $p<0.05$.

RESULTS

In this study, the nutrient contents, silage quality, *in vitro* digestibility and energy contents of silages prepared by harvesting forage turnip in different vegetation periods and mixing with triticale at different ratios were investigated. The nutrient contents of the forage turnip and triticale mixtures before ensiling are presented in Table 2.

There were differences in the DM, OM, CA, NDF and ADF values of the groups before ensiling. With the progression of the vegetation period, increases were observed in the DM, NDF and ADF values of the mixtures.

The nutrient contents of the forage turnip silages are shown in Table 3. It was found that vegetation period had significant effects on the differences between the groups ($p<0.05$). The effects of different ratios of the mixture on the differences between the groups in terms of nutrient contents were also found significant, except for ADF. Moreover, the effects of the vegetation period × mixture ratio interaction on the nutrient contents of these silages were found significant ($p<0.05$), except for EE and NDF.

Fermentation values of silages are among the important criteria determining silage quality. In this study, the effects of the vegetation period on the differences between the silage fermentation values of the groups were found significant ($p<0.05$), except for PA and pH. The effects of the mixture ratio on these differences were insignificant in terms of PA, while they were significant for the other parameters and Fleig scores.

The quality levels of the silages examined in the trial indicated by their Fleig scores were determined as excellent. Additionally, the vegetation period × mixture ratio interaction had significant effects on the silage fermentation values ($p<0.05$), except for LA and PA (Table 4).

According to the results on the in vitro DM and OM digestibility values of the forage turnip silages in this study (Table 5), the effects of the vegetation period and mixture ratio on the differences between the groups were determined to be significant ($p<0.05$). The effects of the vegetation period × mixture ratio interaction were insignificant regarding in vitro DM digestibility and significant ($p<0.05$) regarding in vitro OM digestibility and energy values.

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

Groups	Mixture Type	DM, %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
Beginning of the flowering	100% FT (Control)	15.69	91.30	8.70	9.47	1.30	48.83	35.85
	90% FT +10% T	16.33	91.65	8.35	8.58	1.46	48.90	33.86
	80% FT +20% T	16.21	92.29	7.71	6.04	1.16	48.05	33.30
	70% FT +30% T	16.93	92.36	7.64	6.54	1.85	47.73	29.15
	60% FT +40% T	17.22	91.91	8.09	8.82	1.44	48.68	30.53
Middle of the flowering	100% FT (Control)	19.69	92.61	7.39	9.50	2.82	50.57	38.82
	90% FT +10% T	19.95	93.42	6.58	7.35	1.69	55.82	37.90
	80% FT +20% T	20.2	93.69	6.31	6.46	1.82	56.24	37.58
	70% FT +30% T	20.35	93.09	6.91	8.84	1.13	53.45	37.63
	60% FT +40% T	20.56	92.64	7.36	7.32	2.04	53.73	37.88
Beginning of the capsulation	100% FT (Control)	22.97	94.05	5.95	8.75	2.58	56.38	40.81
	90% FT +10% T	23.29	94.67	5.33	6.74	1.80	55.08	39.15
	80% FT +20% T	24.72	94.16	5.84	8.99	1.90	57.78	38.65
	70% FT +30% T	25.78	94.00	6.00	7.59	1.74	56.51	37.73
	60% FT +40% T	25.85	93.72	6.28	7.11	1.51	56.16	36.95

DM: dry matter, OM: organic matter, CA: crude ash, CP: crude protein, EE: ether extract, NDF: neutral detergent fiber, ADF: acid detergent fiber; FT: Forage turnip T: Triticale

Table 3. Nutrient contents of forage turnip silages (DM, %; Means ±SE).

Period		n	DM, %	OM, %	CA, %	CP, %	EE, %	NDF, %	ADF, %
Beginning of the flowering		20	16.30±0.10^{c}	91.83±0.14^{c}	8.17±0.14^{a}	9.18±0.17^{a}	3.06±0.21^{a}	50.68±0.44^{b}	36.13±0.33^{b}
Middle of the flowering		20	18.15±0.13^{b}	92.34±0.08^{b}	7.66±0.08^{b}	8.53±0.09^{b}	2.36±0.21^{b}	54.45±0.53^{a}	39.44±0.47^{a}
Beginning of the capsulation		20	23.95±0.26^{a}	93.48±0.07^{a}	6.52±0.07^{c}	7.73±0.06^{c}	2.22±0.15^{b}	54.35±052^{a}	38.50±0.46^{a}
	P-value		0.000	0.000	0.000	0.000	0.001	0.000	0.000
Mixture									
100% FT (Control)		15	18.99±0.65^{c}	92.96±0.16^{a}	7.04±0.16^{c}	8.57±0.16^{a}	1.90±0.12^{c}	50.97±0.56^{d}	38.75±0.64
90% FT +10% T		15	19.31±0.74^{bc}	92.88±0.19^{a}	7.12±0.19^{c}	8.00±0.08^{b}	2.90±0.26^{ab}	52.08±0.63^{cd}	38.09±0.61
80% FT +20% T		15	19.59±0.91^{ab}	92.54±0.22^{b}	7.46±0.22^{b}	8.60±0.17^{a}	2.99±0.29^{a}	53.26±0.53^{bc}	37.81±0.44
70% FT +30% T		15	19.82±1.00^{a}	92.35±0.19^{b}	7.65±0.19^{b}	8.59±0.28^{a}	2.51±0.26^{abc}	54.86±0.56^{a}	38.13±0.62
60% FT +40% T		15	19.61±1.11^{ab}	92.02±0.28^{c}	7.98±0.28^{a}	8.70±0.28^{a}	2.29±0.25^{bc}	54.63±1.04^{ab}	37.48±0.90
	P-value		0.000	0.000	0.000	0.000	0.005	0.000	0.443
Period x mixture			0.000	0.000	0.000	0.000	0.251	0.089	0.005
Beginning of the flowering	100% FT (Control)	5	16.45±0.30	92.68±0.17^{a}	7.32±0.08^{d}	9.14±0.15^{b}	1.93±0.61^{b}	49.00±0.52^{c}	37.11±0.55^{a}
	90% FT +10% T	5	16.70±0.16	92.24±0.10^{b}	7.76±0.10^{c}	8.05±0.21^{c}	3.24±0.58^{a}	49.79±0.41^{bc}	35.72±0.35^{ab}
	80% FT +20% T	5	16.06±0.14	91.99±0.11^{b}	8.01±0.11^{c}	8.81±0.17^{b}	3.73±0.25^{a}	51.97±1.08^{ab}	36.83±0.38^{a}
	70% FT +30% T	5	16.10±0.24	91.50±0.10^{c}	8.50±0.10^{b}	9.89±0.29^{a}	3.24±0.34^{a}	52.87±0.72^{a}	36.69±0.78^{a}
	60% FT +40% T	5	16.19±0.27	90.74±0.15^{d}	9.26±0.15^{a}	10.01±0.21^{a}	3.54±0.24^{a}	50.21±0.83^{bc}	34.33±0.41^{b}
	P-value		0.158	0.000	0.000	0.000	0.016	0.021	0.018
Middle of the flowering	100% FT (Control)	5	18.35±0.11^{a}	92.52± 0.10	7.48±0.13	8.65±0.18^{ab}	1.74±0.32	51.28±0.76^{c}	38.72±0.97
	90% FT +10% T	5	18.13±0.09^{a}	92.59± 0.13	7.41±0.13	8.04±0.09^{c}	3.19±0.11	54.07±0.68^{b}	39.71±0.97
	80% FT +20% T	5	18.56±0.05^{a}	92.03± 0.24	7.97±0.24	8.99±0.24^{a}	2.44±0.62	54.05±0.72^{b}	37.79±0.97
	70% FT +30% T	5	18.50±0.38^{a}	92.43± 0.13	7.57±0.13	8.45±0.05^{bc}	2.22±0.53	56.31±0.91^{ab}	39.65±0.63
	60% FT +40% T	5	17.20±0.18^{b}	92.14± 0.07	7.86±0.07	8.54±0.16^{abc}	2.08±0.34	56.83±0.79^{a}	41.38±0.83
	P-value		0.001	0.093	0.093	0.012	0.367	0.000	0.137
Beginning of the capsulation	100% FT (Control)	5	22.16±0.14^{d}	93.69±0.06^{a}	6.31±0.09^{b}	7.94±0.05^{a}	1.96±0.30	52.63±0.78^{b}	40.43±0.34
	90% FT +10% T	5	23.10±0.15^{c}	93.80±0.06^{a}	6.20±0.06^{b}	7.91±0.09^{a}	2.27±0.42	52.94±0.86^{b}	38.85±0.34
	80% FT +20% T	5	24.16±0.10^{b}	93.60±0.13^{a}	6.40±0.13^{b}	7.85±0.20^{ab}	2.95±0.39	53.77±0.76^{ab}	38.81±0.69
	70% FT +30% T	5	24.87±0.17^{a}	93.12±0.08^{b}	6.88±0.08^{a}	7.43±0.03^{c}	2.22±0.35	55.28±0.63^{ab}	37.75±1.33
	60% FXT +40% T	5	25.46±0.10^{a}	93.18±0.15^{b}	6.82±0.15^{a}	7.56±0.09^{bc}	1.71±0.07	56.85±1.63^{a}	36.73±1.10
	P-value		0.000	0.001	0.001	0.004	0.073	0.039	0.103

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 ($P<0.05$); FT: Forage turnip T: Triticale

Table 4. Fermentation quality and Fleig scores of forage turnip silages (Means ±SE)

Period		n	NH_3-N mg.dl^{-1}	LA, %	AA, %	PA, %	pH	Fleig scores	Qualifications class
Beginning of the flowering		20	73.56±1.74^{a}	4.35±0.19^{a}	0.71±0.04^{a}	0.06±0.01	3.86±0.03	83.24±1.20^{c}	EXCELLENT
Middle of the flowering		20	61.52±1.87^{c}	4.16±0.15^{a}	0.41±0.02^{b}	0.04±0.01	3.81±0.04	89.88±1.89^{b}	EXCELLENT
Beginning of the capsulation		20	67.38±1.73^{b}	2.82±0.08^{b}	0.28±0.01^{c}	0.15±0.08	3.81±0.01	100.58±0.71^{a}	EXCELLENT
P-value			0.000	0.000	0.000	0.300	0.102	0.000	
Mixture									
100% FT (Control)		15	72.01±1.25^{a}	4.30±0.30^{a}	0.43±0.04^{bc}	0.24±0.13	3.77±0.03^{b}	92.58±1.84^{a}	EXCELLENT
90% FT +10% T		15	64.23±2.04^{b}	3.43±0.25^{b}	0.40±0.04^{c}	0.04±0.01	3.78±0.03^{b}	92.65±1.09^{a}	EXCELLENT
80% FT +20% T		15	65.16±2.51^{b}	3.88±0.29^{ab}	0.49±0.06^{ab}	0.04±0.01	3.79±0.03^{b}	91.85±2.27^{a}	EXCELLENT
70% FT +30% T		15	67.70±4.10^{ab}	3.70±0.27^{b}	0.49±0.09^{ab}	0.06±0.02	3.83±0.04^{b}	91.58±2.93^{a}	EXCELLENT
60% FT +40% T		15	67.58±1.92^{ab}	3.48±0.18^{b}	0.54±0.08^{a}	0.06±0.01	3.96±0.05^{a}	87.30±3.74^{b}	EXCELLENT
P-value			0.036	0.002	0.005	0.132	0.000	0.000	
Period x mixture			0.000	0.062	0.000	0.053	0.000	0.000	
Beginning of the flowering	100% FT (Control)	5	75.35±1.03^{ab}	5.39±0.70^{a}	0.57±0.06^{bc}	0.04±0.02	3.84±0.03^{a}	84.15±1.57^{b}	EXCELLENT
	90% FT +10% T	5	68.76±4.69^{bc}	4.28±0.19^{b}	0.52±0.06^{c}	0.05±0.02	3.68±0.05^{b}	91.13±2.13^{a}	EXCELLENT
	80% FT +20% T	5	75.73±1.58^{ab}	4.19±0.27^{b}	0.75±0.03^{ab}	0.05±0.03	3.87±0.02^{a}	82.16±1.05^{b}	EXCELLENT
	70% FT +30% T	5	82.89±2.21^{a}	4.17±0.34^{b}	0.87±0.09^{a}	0.11±0.03	3.97±0.05^{a}	78.24±2.10^{b}	GOOD
	60% FT +40% T	5	65.32±0.22^{c}	3.50±0.18^{b}	0.83±0.07^{a}	0.06±0.03	3.92±0.06^{a}	80.49±2.61^{b}	GOOD
P-value			0.007	0.010	0.003	0.153	0.001	0.002	
Middle of the flowering	100% FT (Control)	5	71.31±1.70^{a}	4.22±0.32	0.40±0.05	0.05±0.03	3.67±0.06^{b}	97.15±1.54^{a}	EXCELLENT
	90% FT +10% T	5	67.00±2.86^{a}	3.64±0.33	0.41±0.03	0.04±0.01	3.81±0.06^{b}	90.97±1.00^{b}	EXCELLENT
	80% FT +20% T	5	55.39±1.72^{b}	4.60±0.53	0.44±0.01	0.03±0.02	3.70±0.05^{b}	92.82±2.02^{ab}	EXCELLENT
	70% FT +30% T	5	53.40±4.02^{b}	4.33±0.19	0.35±0.02	0.02±0.01	3.72±0.05^{b}	93.19±2.44^{ab}	EXCELLENT
	60% FT +40% T	5	65.13±1.89^{a}	3.99±0.15	0.47±0.03	0.08±0.02	4.17±0.06^{a}	74.44±2.11^{c}	GOOD
P-value			0.002	0.351	0.152	0.143	0.000	0.000	
Beginning of the capsulation	100% FT (Control)	5	69.19±2.15^{a}	3.29±0.13^{a}	0.31±0.02	0.57±0.66	3.80±0.03^{b}	97.33±1.27^{c}	EXCELLENT
	90% FT +10% T	5	57.84±0.62^{b}	2.59±0.15^{b}	0.27±0.01	0.02±0.01	3.85±0.02^{a}	96.25±0.80^{c}	EXCELLENT
	80% FT +20% T	5	66.47±2.51^{ab}	2.84±0.17^{b}	0.29±0.02	0.05±0.01	3.81±0.01^{ab}	100.76±0.09^{b}	EXCELLENT
	70% FT +30% T	5	72.89±4.60^{a}	2.59±0.11^{b}	0.25±0.01	0.03±0.01	3.79±0.01^{b}	103.30±0.52^{a}	EXCELLENT
	60% FT +40% T	5	70.90±4.16^{a}	2.77±0.02^{b}	0.27±0.01	0.03±0.01	3.79±0.01^{b}	104.39±0.46^{a}	EXCELLENT
P-value			0.029	0.015	0.181	0.113	0.038	0.000	

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

Table 5. In vitro digestibility values and energy contents of forage turnip silages (Means ±SE)

Period		n	DMD, %	OMD, %	DE, Mcal. Kg^{-1} DM	ME, Kcal. kg^{-1} DM	NEL, Mcal. kg^{-1} DM
Beginning of the flowering		20	60.57±0.54^{a}	64.63±0.62^{a}	2.85±0.03^{a}	2.34±0.02^{a}	1.47±0.01^{a}
Middle of the flowering		20	55.41±0.77^{b}	58.57±0.89^{b}	2.58±0.04^{b}	2.12±0.03^{b}	1.31±0.02^{b}
Beginning of the capsulation		20	51.17±0.60^{c}	53.73±0.64^{c}	2.37±0.03^{c}	1.94±0.02^{c}	1.20±0.02^{c}
P-value			0.000	0.000	0.000	0.000	0.000
Mixture							
100% FT (Control)		15	53.77±1.45^{b}	56.81±1.69^{c}	2.55±0.08^{ab}	2.09±0.06^{ab}	1.29±0.04^{ab}
90% FT +10% T		15	56.43±1.74^{a}	58.89±2.04^{b}	2.60±0.09^{b}	2.13±0.07^{b}	1.32±0.05^{b}
80% FT +20% T		15	57.22±1.20^{a}	61.54±1.41^{a}	2.71±0.06^{a}	2.23±0.05^{a}	1.39±0.03^{a}
70% FT +30% T		15	56.78±1.15^{a}	59.37±1.33^{b}	2.62±0.06^{b}	2.15±0.05^{b}	1.34±0.03^{b}
60% FT +40% T		15	54.42±1.41^{b}	56.67±1.59^{c}	2.50±0.07^{c}	2.05±0.06^{c}	1.27±0.04^{c}
P-value			0.004	0.000	0.001	0.001	0.001
Period x mixture			0.078	0.008	0.014	0.015	0.015
Beginning of the flowering	100% FT (Control)	5	58.94±1.69	61.68±0.30^{b}	2.78±0.06	2.28±0.05	1.42±0.03
	90% FT +10% T	5	62.31±1.69	66.79±1.50^{a}	2.95±0.07	2.42±0.05	1.52±0.04
	80% FT +20% T	5	61.32±0.46	66.35±0.96^{a}	2.93±0.04	2.40±0.03	1.51±0.02
	70% FT +30% T	5	60.31±1.17	63.96±0.90^{ab}	2.82±0.04	2.31±0.03	1.45±0.02
	60% FT +40% T	5	60.06±0.54	63.28±1.08^{ab}	2.79±0.05	2.29±0.04	1.43±0.03
P-value			0.317	0.031	0.104	0.115	0.102
Middle of the flowering	100% FT (Control)	5	54.10±1.15^{bc}	59.29±1.15^{ab}	2.62±0.07^{ab}	2.14±0.06^{ab}	1.33±0.04^{ab}
	90% FT +10% T	5	54.87±2.00^{abc}	56.58±1.70^{bc}	2.49±0.06^{bc}	2.04±0.05^{bc}	1.27±0.03^{bc}
	80% FT +20% T	5	58.81±0.88^{a}	62.72±0.83^{a}	2.77±0.04^{a}	2.27±0.03^{a}	1.42±0.02^{a}
	70% FT +30% T	5	56.80±0.78^{ab}	59.19±0.72^{ab}	2.61±0.03^{ab}	2.14±0.03^{ab}	1.33±0.02^{ab}
	60% FT +40% T	5	51.48±0.67^{c}	53.47±1.25^{c}	2.36±0.05^{c}	1.93±0.05^{c}	1.19±0.03^{c}
P-value			0.022	0.001	0.001	0.001	0.002
Beginning of the capsulation	100% FT (Control)	5	48.27±1.10	51.31±1.48	2.27±0.06	1.85±0.06	1.14±0.03
	90% FT +10% T	5	50.67±0.75	52.72±0.25	2.33±0.01	1.91±0.04	1.17±0.01
	80% FT +20% T	5	52.56±0.24	55.55±0.48	2.45±0.02	2.01±0.02	1.24±0.01
	70% FT +30% T	5	52.06±0.84	54.94±2.12	2.42±0.09	1.99±0.02	1.23±0.05
	60% FT +40% T	5	52.40±1.74	54.11±1.37	2.39±0.06	1.96±0.03	1.21±0.03
P-value			0.072	0.209	0.216	0.198	0.211

DMD: dry matter digestibilty, OMD: organic matter digestibilty, DE: Digestible Energy, ME: Metabolic Energy NE: Net Energy Lactation; FT: Forage turnip T: Triticale. a,b,c: Means with different superscripts in the same column are significantly different ($p<0.05$).

DISCUSSION

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 digestibility and energy content of silages of forage turnip prepared at different vegetative stages and different ratio of triticale mixing were investigated.

As seen in Table 2, there were differences in the DM, OM, CA, NDF and ADF values of the groups before ensiling. With the progression of the vegetation period, increases were observed in the DM, NDF and ADF values of the mixtures. In their study on forage turnip (*Brassica rapa L.*), Daş (2019) reported the contents of DM, CA, CP, ADF and NDF before ensiling as 18.06%, 8.81%, 10.35%, 38.71% and 42.14%, respectively. The DM and CA values they reported were similar to those in this study, while their CP and ADF values were higher, and their NDF values were lower. Çetin (2017) reported the DM, CA, CP, NDF and ADF values of fresh forage turnip by the end of flowering as 23.33%, 10.04%, 19.96%, 36.04% and 26.98%, respectively. In comparison to the values that were obtained in this study, the DM, NDF and ADF values reported by Çetin were lower, while the CA and CP values they reported were higher.

In the examination of the nutrient contents of the silages obtained by mixing forage turnip and triticale (Table 3). In silages obtained by adding 5% wheat to three different species in the *Brassica* genus (Forage turnip (*Brassica rapa*), black mustard (*Brassica nigra*) and canola (*Brassica napus L.*)), silage quality and *in vitro* digestibility values were investigated by Kılıc and Erisek (2019). The study revealed the DM, CA, EE, CP, NDF and ADF values of the additive-free and wheat-added forms respectively as 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% for forage turnip. In comparison to the values obtained in this study, their DM, CA, NDF and ADF values were higher, and their CP and EE values were lower. In the silages of the forage turnip plants harvested at the end of the flowering period and ensiled without additives, Daş (2019) determined the DM, CA, CP, NDF and ADF contents as 18.17%, 7.97% 9.83%, 50.24% and 46.61%, respectively. In comparison to the values of the additive-free silages prepared with forage turnip collected at the end of the flowering period in this study, the DM and NDF values reported by Daş (2019) were lower, whereas their CA, CP and ADF values were higher. Another study (Özkan, 2019) revealed the DM, CA, CP, EE, NDF and ADF values of additive-free forage turnip silages as 23.18%, 9.65%, 12.53%, 2.92%, 41.05% and 27.62%, respectively. The DM, CA, CP and EE values they reported were higher than those of the additive-free silages in this study, while their NDF and ADF values were lower.

The effects of the vegetation period on the differences between the groups were significant in terms of the NH_3-N, LA, AA values and Fleig scores but insignificant in terms of the PA and pH values (Table 4). It was determined that as the vegetation period progressed, the LA and AA values of the silages decreased, and their Fleig scores increased. The pH values of the silages were within the optimum range. In proportion to the CP contents of the silages, their NH_3-N values were the highest at the beginning of flowering, followed by the end of flowering, and the lowest values were obtained in the mid-flowering period. Regarding the fermentation parameters, the effects of the triticale forage ratio were insignificant in terms of PA and significant in terms of the NH_3-N, LA, AA, pH values and Fleig scores. While the addition of triticale forage lowered the LA values of the silages, it increased their AA levels. The pH level of the silages in which 40% triticale forage was added found the highest in comparison to the other silages, but this value (3.96) was still in the optimum range. The Fleig scores of the silages were lower with the addition of 40% triticale forage, but all silages provided "excellent" Fleig scores. Moreover, the effects of the vegetation period × mixture ratio interaction were significant on the NH_3-N, AA, pH and Fleig score values of the silages (Table 4). Kılıc and Erisek (2019) investigated the effects of wheat addition on the quality and *in vitro* true digestibility (IVTD) values of silages obtained from forage turnip. They found the LA levels of the additive-free and 5% wheat-added forage turnip silage as 1.16% and 4.01%, the AA levels were 2.22% and 1.87%, the pH values were, 5.05 and 5.03, the Fleig scores were 32.11 and 36.89, respectively. Regarding the additive-free silages, the pH and AA values reported by Kılıc and Erisek (2019) were higher than those in this study, whereas their LA values and Fleig scores were lower. In their study conducted with forage turnip (*Brassica rapa L.*), Daş (2019) reported the pH, NH_3-N/TN, LA, AA and PA values of additive-free silages as 4.55, 10.32%, 3.69%, 3.18% and 0.05%, respectively. The pH, LA, PA and AA values reported by Daş (2019) were higher than those in this study, while their NH_3-N levels were lower. Özkan (2019) found the pH, NH_3-N, LA, AA and Fleig score values of forage turnip silage respectively as 4.20, 74.60, 5.72%, 2.91% and 83.36. The pH, NH_3-N, LA and AA values in the study by Özkan (2019) were higher than the values that were determined in this study, while their Fleig scores were lower. In another study (Çetin, 2017), the pH, LA, AA, PA and Fleig score values of additive-free forage turnip silages were reported as 3.80, 1.98%, 0.23%, 0.16% and 108.05, respectively. These values were similar to the results in this study.

In terms of the *in vitro* DM and OM digestibility values and energy contents of the forage turnip silages, the effects of vegetation period and mixture ratio were found significant. As the vegetation period progressed, the DMD and OMD values of the silages decreased. This effect was also reflected on the DE, ME and NE_L levels of the silages. Likewise, in comparison to the control group, the highest DMD, OMD, DE, ME and NE_L values were observed in the silages in which triticale forage was added at a ratio of 20%. The effects of the vegetation period × mixture ratio interaction were also significant on the *in vitro* digestibility and energy content values of the silages, except for the DMD parameter (Table 5). In a study (Kılıc and Erisek, 2019), the IVD values of additive-free forage turnip silage were found as 54.89%. The value reported by the researcher was similar those obtained in this study. In another study, the *in vitro* organic matter digestibility (IVOMD) and ME values of silages obtained by adding wheat straw and molasses to forage turnip at different ratios were reported respectively for the control and 10% straw groups as 50.18% and 50.07% and 7.69 and 7.63 $MJ.kg^{-1}$ DM (Daş 2019). The IVOMD and ME values reported by the researcher were lower than those obtained in this study.

Conclusion: All forage turnip silages were in the quality category based on their fermentation qualities and Fleig scores, while the highest-quality silages in terms of *in vitro* digestibility and energy content values were obtained with the addition of triticale forage at a ratio of 20% to forage turnip collected at the beginning of the flowering period. However, if the OMD and energy values obtained in such studies are correlated with the amount of organic matter obtained from the unit area, more meaningful results will be achieved.

Funding: This study was supported by Van Yüzüncü Yıl University, Scientific Research Projects Coordination Unit, as Basic Research Project numbered FBA-2019-8110.

Ethical Statement: For this study, it was decided that there is no need to obtain "Study and Research Final Results Approval Certificates" in accordance with the relevant article of the regulation, dated 15/03/2019-21992 of Van Yüzüncü Yıl University, Animal Experiments Local Ethics Committee.

Disclosure statement: No potential conflict of interest was reported by the authors.

REFERENCES

Ankom, (2002). Operator's Manual ANKOM ll 200/220 Fiber Analyzer. ANKOM Technology Corp., Fairport, NY.

Anonymous, (2022a). Feeding Canola (Grass Type Feed Turnip, Lenoks). https://www.amasyadsyb.org/sut/yembitki/9 (Access time: 02 February 2022).

Anonymous, (2022b). What are general information about Lenoks (Grass Type Forage Turnip)? http://bursaplant.blogspot.com/2016/09/lenox-yem-salgam-yetistiriciligi.html?view =magazine (Access time: 02 February 2022).

AOAC. (1990). Association of Official Analytical Chemists. Official Methods of Analysis. 1. 15th ed. AOAC, Arlington, VA.

Çetin, İ. (2017). Determination of some quality properties of ensiling turnip (*Brassica Rapa L.)* with different additives. Master Thesis. Uşak University Institute of Science and Technology, Uşak.

Daş, B.D. (2019). The Effect of different levels of wheat straw and dried molasses sugar beet pulp on the silage quality, live weight gain in lambs and digestibility of lenox (*Brassica rapa L.)* silage. Ph. D. Thesis. Harran University, Health Sciences Institute, Şanlıurfa, Turkey.

Dogan D. B. and N. Denek (2021). Effect of wheat straw and molasses supplementation on quality, lamb performance, and digestibility of forage turnip (*Brassica rapa*) silage. Iranian J. Appl. Anim. Sci., 11(3), 547-555

Goering, M.K. and P.J.V. Soest (1970). Forage Fibre Analysis. Agricultural Handbook, No.379. Agric. Res., U.S. Dep. Agric.

Harmanşah, F. (2018). Potential and importance of triticale in forage production in Turkey. TURKTOB Magazine, (27); 37-38

Ishler, V., J. Heinrichs and G. Varga (2000). From Feed to Milk: Understanding rumen function. Penn State Uni. College of Agri. Sci. Extension Circular 422. USA.

Karadağoğlu, Ö. and M.L. Özdüven (2019). Effects of fermentation characteristics and feed value of some triticale cultivars ensiled at different stages of maturity. J. of Turkish Vet. Med. Soc. 90 (2): 132-142, DOI: 10.33188/vetheder.499308

Kavut, Y.T., H. Soya, H. Geren, R. Ünsal, İ. Sevim and R. Avcıoğlu (2012). Investigations on the herbage yield for silage and silage quality characteristics of some triticale cultivars grown under Menemen conditions. Anadolu, J. of AARI 22 (1), 33 – 44

Kılıc, U. and A. Erisek (2019). Effects of additive use on silage quality and in-vitro digestibility of some brassica silages. J. of Sci. and Engineering Res. 6(11):163-171

Kılıç, A. (1986). Silo Feed (Teaching, Learning and Practice Advice). 327 pages. Bilgehan Press, Izmir. Turkey

Kilic, U. (2009). Using canola forage as roughage source in ruminant nutrition. J. of Lalahan Lives. Res. Inst. 49 (2); 125-135

Markham, P. (1942). A steam distilation apparatus suitable for micro-kjeldahl analyses. J. Biochem. 36: 790-797.

NRC. (1989). Nutrient Requirements of Dairy Cattle. 6th evised Edit., National Acedemy Press Washington D.C., USA

Özkan, F. (2019). Determining the quality of sugar beet pulp, lenox and ryegrass silages used in feeding dairy cattle, in comparison with corn silage, Ph.D. Thesis, Van Yüzüncü Yıl University, Health Sciences Institute, Van, Turkey.

Polan, C.E., T.M. Starling, J.T. Huber, C.N. Miller, R.A. Sandy (1968). Yields, composition and nutritive evaluation of barley silage at three stages of maturity for lactating cows. J. Dairy Sci., 51:1801-5.

SPSS. IBM SPSS statistics version 13.0 for Windows. New York: IBM Corp.

Steel, R.C.D. and J.H. Torrie (1980). Principles and Procedures of Statistics. A Biometrical Appoach. Mc Graw- Hill Book Company New York.

Suzuki, M. and C.W. Lund (1980). Improved gas-liquid chromatography for simultaneous determination of volatile fatty acids and lactic acid in silage. J. Agri. Food Chem., 28: 1040-1

Tiryakioglu, H. and M. Turk (2012). Effects of different sowing and harvesting times on yield and quality of forage turnip (*Brassica rapa L.*) Grown as a second crop. Turk. J. Field Crops, 17(2):166-170

Undersander, D. J., A. R. Kaminski, E. A. Oelke, L. H. Smith, J. D. Doll, E. E. Schulte and E. S. Oplinger (1991). Turnip. In: Alternative field crops manual. Wisconsin and Minnesota Cooperative Exten., Univ. of Wisconsin, Madison, and Univ. of Minnesota. www.hort.purdue.edu/newcrop/afcm/turnip.html (Access time: 20 January 2022).

Yıldız, S., S. Erdoğan and M. Demirel (2019). Effect of silage volatile fatty acid content on some milk and meat yield and quality properties. YYU J INAS, 24(1); 64-71

Yıldız, S. (2019). The Effect of silage fermentation products on feed consumption, rumen content and blood parameters. 112-131. In: Research Papers in the Field of Agriculture, Forestry and Fisheries, Daşdemir İ., Atik HA., Özden Ö., Eds., Gece Kitaplığı, ISBN: 978-625-7958-10-3 Ankara, Turkey.

Yıldız, S., S. Deniz, F. Özkan and Ç. Kale (2022a). Forage turnip (*Brassica rapa*) harvested in different phases of vegetative stage andensiled with the additives of molasses and barley and the effects of additives on silage quality, in vitro digestibility, and energy content. Turk. J. Vet. Anim. Sci. 46 (3), 475-482 Doi: 10.55730/1300-0128.4196

Yıldız, S., S. Deniz, F. Kizilırmak and S. Altaçlı (2022b). The effects of making silage at different ratios of sunflower and sugar beet on silage quality, in-vitro digestibility and energy content. J. Inst. Sci. and Tech. 12 (2), 1154-1162, Doi: 10.21597/jist.1038616.