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Determination of Silage Quality of Fenugreek (*Trigonella foenum-graecum* L.) with Oat (*Avena sativa* L.) and Rye (*Secale cereale* L.) Mixtures

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Abstract: In this study, it was aimed to determine the quality of silage mixtures (100:0%, 75:25%, 50:50%, 25:75% and 0:100%) of fenugreek (*Trigonella foenum-graecum* L. cv Berkem) with oat (*Avena sativa* L. cv Faikbey) and rye (*Secale cereale* L. cv Aslım-93). Following the harvest, plants were cut in 2-3 cm sizes, filled in vacuum bags according to the mixing ratios and left for fermentation at 25±2 ºC for 60 days. Physical observations (odor, structure, color), dry matter (DM), pH, crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) analysis were applied to silage samples and relative feed value (RFV) was determined. According to the results obtained, the total physical score of the silages, consisting of the sum of the odor, structure and color scores, ranged between 13.30-19.75 and the physical quality of the silages was ranged between middle-very good class. According to the results of the research, it was determined that the silage DM, ADF and NDF ratios decreased, and the pH, CP and RFV values increased in parallel with the increase in the fenugreek ratio in the mixture. The DM, pH, CP, ADF, NDF and RFV values of the silages varied between 15.67-34.33%, 5.06-5.79%, 6.01-18.17%, 32.03-48.90%, 40.07-74.53% and 63.41-148.48, respectively. As a result, it was concluded that the silage of "25% oats + 75% fenugreek" mixture was superior to the silages of other mixtures, especially when considered the chemical parameters.

Çemen (*Trigonella foenum-graecum* L.) ile Yulaf (*Avena sativa* L.) ve Çavdar (*Secale cereale* L.) Karışımlarının Silaj Kalitesinin Belirlenmesi

Anahtar Kelimeler
Silaj, Yulaf, Çavdar, Çemen, Fiziksel özellikler, Nispi yem değeri

Öz: Bu çalışmada, çemen (*Trigonella foenum-graecum* L. cv Berkem) ile yulaf (*Avena sativa* L. cv Faikbey) ve çavdar (*Secale cereale* L. cv Aslım-93) karışımlarının (%100:0, %75:25, %50:50, %25:75 ve %0:100) silaj kalitesinin belirlenmesi amaçlanmıştır. Hasat edilen bitkiler 2-3 cm boyutlarında parçalandıktan sonra karışım oranlarına göre vakum poşetlere doldurulmuş ve 60 gün süre ile 25±2 ºC'de fermantasyona bırakılmıştır. Silaj örneklerinde; fiziksel gözlemler (koku, strüktür, renk) ve kuru madde (KM) analizi ile pH, ham protein (HP), asit deterjanda çözülmeyen lif (ADF) ve nötral deterjanda çözülmeyen lif (NDF) gibi kimyasal analizler yapılmış, silaj materyallerinin nispi yem değeri (NYD) belirlenmiştir. Elde edilen sonuçlara göre, silajların koku, strüktür ve renk puanları toplamından oluşan toplam fiziksel puanı 13.30-19.75 arasında değişmiş ve silajların fiziksel kalitesi orta ile çok iyi sınıfında yer almıştır. Araştırma sonucuna, göre karışımdaki çemen oranının artışına paralel olarak silaj KM, ADF ve NDF oranlarının azaldığı, pH, HP ve NYD değerlerinin arttığı belirlenmiştir. Silajların KM, pH, HP, ADF, NDF ve NYD değerlerinin sırasıyla %15.67-34.33, 5.06-5.79, %6.01-18.17, %32.03-48.90, %40.07-74.53 ve 63.41-148.48 arasında değişim göstermiştir. Sonuç olarak, özellikle kimyasal parametreler dikkate alındığında %25 yulaf+%75 çemen karışımı silajının diğer karışımlardan elde edilen silajlardan daha üstün olduğu sonucuna varılmıştır.

1. INTRODUCTION

A cheap feed source, roughage is very important for farm animals due to its contents of nutrients necessary for the stomach microflora of ruminant animals [1]. In general, high quality roughage sources consist of forage crops grown in pasture-rangelands and field agriculture. In Türkiye, animals are not fed adequately and in a balanced way [2] there is a shortage of approximately 56 million tons of roughage [3]. With the rapid development of animal husbandry, the demand for high-quality green forage throughout the year is also increasing. Increasing the productivity of pasture-rangelands and the cultivation and production of forage crops are of great importance in closing the current forage deficit. In this sense, there was a significant increase in silage production in recent years, especially as a solution to quality roughage problem. Silage is a high-moisture-content forage that is used to feed livestock. Using silage as feed is economically feasible and suitable for cattle management [4]. Silage making is considered to be the most effective and economical method for the preservation of green fodder. Silage production technique plays a role in silage quality, as well as the characteristics of the silage material. For this purpose, many plants can be used to make silage, either sole or in mixtures.

Oat (*Avena sativa*) is an annual crop well known in temperate climates [5] and it is produced for grain and forage in many countries [6]. Oat has multifunctional uses such as forage, fodder, straw for bedding, hay, haylage, silage chaff, human food as rolled or crushed into meal or flour [7]. Oat is a functional food [5] with identified 113 phytochemicals in its content [8]. It contains a spectrum of phenolics and avenanthramides [9]. The mixed-linkage β-glucan is a water-soluble dietary fibre as considered the main biologically active component of many oat products [10]. *Avena sativa* does not only produce highly nutritious grains, but also valuable forage [11]. Oat is a fast growing, palatable, succulent and nutritious fodder crop [12]. Oat is one of the most important winter forage crops grown for livestock in Türkiye.

Rye (*Secale cereale* L.) is a multi-purpose winter cereal mainly grown in Central and Eastern Europe and in Western Canada [13]. It is an important crop used for food, feed and bioenergy [14]. Rye synthesizes benzoxazinoids which are protective special metabolites [15] which regulate aboveground and belowground biotic interactions [16]. Benzoxazinoids play an important role in disease resistance and have anti-bacterial and anti-fungal activity [17]. *Secale cereale* grains are rich in dietary fibre, phenolic acids, lignans and alkylresorcinols [18]. This crop is a high-quality forage plant. At post-heading stage, biomass of rye increases by up to 30%. But lignification of the cell walls result with low fermentation efficiency and digestibility. Also contamination by mycotoxin-producing fungi may impair the quality of the silage [4]. Whole rye crop harvested at pre-maturity stage is a valuable forage for silage production [19].

Fenugreek (*Trigonella foenum-graecum* L.), grown for its seeds, fresh shoots and leaves, is one of the oldest plants belonging to the legume family known for its medicinal and aromatic properties [20]. Fenugreek is native to the eastern Mediterranean zone but is currently cultivated worldwide. The plant has alkaloids, steroids and sapogenins and plant has an important place in traditional medicine to aid digestion and to improve metabolism. Trigonelline and diaszhenin are the most important metabolites of fenugreek in decreasing blood cholesterol [21]. Nowadays, as feed additives, herbs are get incorporated in the animal diets to increase productivity by improving digestibility, nutrient absorption and pathogen elimination in the gut [22]. Fenugreek seeds are used in animal nutrition as powder, oils or extracts due to its therapeutic properties. Leaves of this plant contains carbohydrates, proteins and minerals, low in lipids. Its oils or extracts have antibacterial and antifungal activities. It helps to circulate nutrients into the cells and to remove the toxic materials from the cells. By hormone precursors content, its seeds increase milk secretion in animals. Fenugreek seeds are used in fish, domestic rabbits and ruminant diets [23].

Mixing different species in silage making is a method used to obtain fodder with high nutritional value. Legumes and cereals are generally used for this purpose [2]. Legume monocultures have a low risk of silage fermentation due to their low water soluble carbohydrate and dry matter (DM) content and high buffering capacity [24; 25]. For this reason, grass-legume silage mixtures are preferred in the direction that cereals will provide fermentable carbohydrates and legumes will improve the protein content of silage. Mixing legumes with cereals for ensiling will not just improve quality of silages but also will diversify forage production of enterprices with multifunctional crops, produce rich feeds with functional phytochemicals (β-glucan etc.), help to breed more healthy and diseases tolerant farm animals and produce more nutritious feeds. Therefore, it is also important to determine the best legume-grass combination ratio during the ensiling process. In addition, there is limited information on the nutritional value of the silage of cereals and fenugreek grown in an intermediate crop period.

This study was conducted to determine the quality properties of silages prepared by mixing oats (*A. sativa* L.) and rye (*S. cereale* L.) with different proportions of fenugreek (*T. foenum-graecum* L.).

2. MATERIAL AND METHOD

2.1. Materials

In the study, oats (*A. sativa* L.), rye (*S. cereale* L.) and fenugreek (*T. foenum-graecum* L.) crops were grown in the 2019-2020 vegetation period in Siirt province which has a semi-arid climate located in the Southeastern Anatolia Region of Türkiye (Figure 1) to prepare silages. "Faikbey" oat variety and "Aslım-93" rye variety was obtained from Bahri Dağdaş International Agricultural Research Institute and "Berkem" fenugreek variety was obtained from Dicle University Faculty of Agriculture.

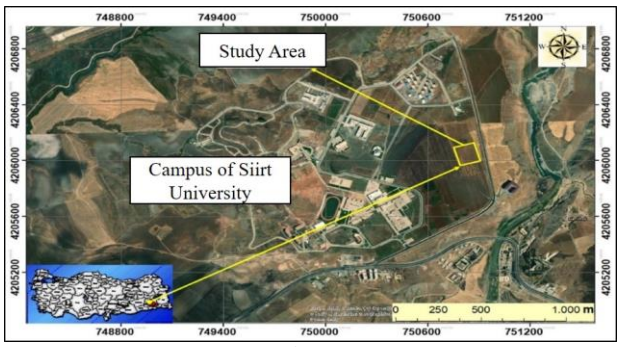

Figure 1. Crop growth location of the silaged plant materials

Soils where silage materials are cultivated was clayey in texture, salt-free, slightly alkaline, moderately calcareous, poor in organic matter content, poor in available phosphorus content and rich in available potassium content. According to long term (1990-2020) meteorological data of the Siirt province the current climate in the region is semi-arid. Average temperature was 11.6 ºC, annual total precipitation was 632.5 mm, and average relative humidity was 59.9% for the long-term average of the region. Average temperature and total precipitation values for 2019-2020 were above the long term averages, while average relative humidity values were below the long term averages [26].

2.2. Methods

Field trial was established during the winter vegetation period of 2019-2020 with three replications according to the randomized complete blocks design. Row spacing was 20 cm, plot length was 12 m and number of rows was 12 for oats and rye in sowing. Seeding rate was 450 seeds m^{-2} for oats, 500 seeds m^{-2} for rye, and 25 kg ha^{-1} for fenugreek. In the research, 60 kg ha^{-1} nitrogen (N) and 140 kg P_2O_5 ha^{-1} phosphorus (P) were given as deficient nutrient element for cereals. Half of the N and whole P were applied to the soil one week before sowing. The remaining half of the N was applied to the cereals when plants were at tillering stage [27]. Fenugreek was planted with 25 cm row spacing, 6 rows and 5 m plot length. At sowing, 30 kg ha^{-1} N and 90 kg ha^{-1} P_2O_5 were applied to fenugreek. Harvest time for silage was pod establishment stage for fenugreek, spike emergence stage for rye and beginning of the clustering period for oats.

Harvested plants were wilted in shade for three hours. The plants, whose wilting processes were completed, were chopped in approximately 2-3 cm dimensions with a branch shredder. The subject of the research was to determine the silage value of the mixtures of fenugreek and oat and rye in different proportions. For this aim, the mixing ratios used in the study were set as 100:0, 75:25, 50:50, 25:75 and for “Rye: Fenugreek” and “Oats: Fenugreek”. Plant materials prepared for silage were weighed, mixed, one kg was taken from each mixture and placed in a special vacuum bag after being compressed. All mixtures were kept in a dark and cool environment for 60 days after being silaged. Packs were checked every week to observe the conditions of the materials.

After the fermentation process was completed, the tanks of matured silages were opened and some physical and chemical analyzes were made on the samples. Physical examinations such as odor, structure and color of the samples on the opened silage bags were conducted subjectively by five experts. The scoring method developed by Anonymous [28] was used in the evaluation of physical analyzes. The silage quality class of the silages was determined according to the DLG (Deutsche Landwirtschafts-Gesellschaft) score (Table 1). The DLG score is the total physical score (0-20 points) obtained by the sum of the scores of odour, structure and color [28; 29].

For the determination of the silage DM content (%), 300 g wet samples were taken from the mature silages and dried in an oven at 65 ºC for 48 hours. The DM ratio was determined by weighing the dried silage samples on a precision scale and proportioning to the wet weight [30].

For the pH value, a part of silage materials representing the bags was taken from each silage bag, then mixed homogeneously and 25 g wet silage sample from this mixture was weighed on a precision balance before put into a mixer. 250 ml of distilled water was placed on the sample and mixed for 10 minutes, then filtered through filter paper and taken into glass beakers. The pH in the filter of approximately 200 ml material was determined by a pH meter [31]. In order to determine the crude protein (CP) ratios of the silages, the silage samples were dried at 65 °C until they reached a constant weight, then were ground in a mill with a sieve diameter of 1 mm in the laboratory and prepared for the analysis. The total N values of these samples were determined by the Kjehldahl method and the CP ratios were determined by multiplying the N values with the coefficient of 6.25 [30]. Analysis of acid detergent fiber (ADF) and neutral detergent fiber (NDF) in silage applications were determined by using ANKOM 200 Fiber Analyzer according to the principles reported by Van Soest [32] and Van Soest and Wine [33].

The relative feed value (RFV), which is an index for the estimation of the energy value of the roughage by the consumption of the animal, was determined with the help of the following equations developed by Van Dyke and Anderson [34]. To calculate this, digestible dry matter (DDM, %) was calculated with the help of Equation 1, dry matter consumption (DMC, %) was calculated with Equation 2, and RFV was determined with the help of Equation 3.

$$DDM\ (\%) = 88.9 - (0.779 \times ADF\%) \quad (1)$$

$$DMC\ (\%) = 120 / NDF\% \quad (2)$$

$$RFV\ (\%) = DDM\% \times DMC\% \times 0.775 \quad (3)$$

According to the RFV data determined in silages, the quality class reported by Rohweder et al. [35], [RFV>151= Top quality, 125-151= 1st quality (very good), 103-124= 2nd quality (good), 87-102= 3rd quality (medium), 75-86= 4th quality (bad) ve RFV<75= 5th quality (unacceptable)] was used to evaluate the quality of the forage.

The data obtained from the study were subjected to the analysis of variance according to the randomized block experimental design. The differences between the groups according to the F-test results were determined by Tukey's multiple comparison test [36].

Table 1. Physical examination key developed by DLG and silage quality class

Physical examination key	
1. Odor	**Score**
No butter acid odor, slightly sour, fruity and aromatic odor	14
A small amount of butter acid, strong sour odor, and slight escalation	8
Moderate butter acid odor, strong escalation-musty odor	4
Strong butter acid or ammonia odor, very slight sour odor	2
Strong decomposition, ammonia or musty odor	0
2. Structure	
Intact leaves and stems	4
A slightly deteriorated structure of leaves	2
A deteriorated structure of leaves and stems, musty and dirty	1
Rotten leaf and stalk	0
3. Color	
Preserved its color at the moment it was silaged (brown in withered silage)	2
Slightly changed color (yellow to brown)	1
Completely changed color (reseda green)	0
Quality class according to the physical properties of silage	
Quality class	**DLG score**
I- Very good	20-18
II- Good	17-14
III- Medium	13-10
IV- Low (low value)	9-5
V- Corrupted (useless)	4-0

3. RESULTS AND DISCUSSIONS

3.1. Silage Physical Properties

In determining the quality of silage feed, physical methods such as color, odor and structure, which are simple and can be applied under all conditions, are also used, and with this method, preliminary information about the quality of silage can be obtained [37]. The scores and quality class results of the physical observation values (odor, structure and color) of the silages obtained by mixing fenugreek with rye and oats in different proportions are given in Table 2.

Silage odor is one of the most important sensory characteristics used to determine silage quality by physical methods. The average odor value of all applications was determined as 12.28 points, and the odor values of oat, rye and fenugreek silage and their mixtures varied between 9.50-14.00 points. In terms of odor, it was observed that sole fenugreek silage, with a score of 9.50, was close to the "strong sour odor and slightly warming" odor. Other applications have a very good and good silage odor in terms of odor in general. In particular, silage consisting of 75% oats+25% fenugreek gave the best result with 14.00 points (Table 2).

In a good silage, leaves and stems are required to preserve their physical structure. In the study, it was determined that the structure of the leaves in "100% fenugreek" silage was slightly deteriorated and showed low structure characteristics with an average score of 2.50. It was observed that the structure of the leaves and stems of the other silages was not deteriorated in general and the silage structures were at the desired levels. In this sense, it has been determined that fenugreek has the highest structure feature of silages at 50:50 mixing ratios with oats and rye (Table 2). The main factor in the preservation of the structure is the fermentation stage, and since the amount of lactic acid increases in a short time in the successfully fermentated silo feed, deterioration, wear or mold formation does not occur on the leaves and stems.

Another physical feature used to determine the quality of silage is color. As can be seen from Table 2, the average color value of the applications was determined as 1.72 points, and the color score values of the silages varied between 1.30-2.00. These values show that all silage applications generally preserve their color when prepared and physically indicates a good silage. Especially among the mixed silages, "75% oats+25% fenugreek" silage gave the best results in terms of color (Table 2).

Total physical scores (DLG) of silage materials ranged between 13.30-19.75. In terms of DLG, "100% fenugreek" silage was in the "medium" silage quality class, while the other silages were in between "good" and "very good" class. According to the average value of all applications, the physical quality of the silages was found to be "good". In general, when the physical properties and DLG scores are evaluated together, it can be said that better quality silage was obtained from "75% oats+25% fenugreek" mixed silage compared to sole silage materials (Table 2).

It was also been revealed in some other studies that the physical properties of silages obtained by mixing legume forage species and cereals in different proportions differ depending on the mixing ratios. In general, higher scores in terms of DLG were obtained from the mixture of legumes with cereals at low rates, as in the findings of our study. For example, highest DLG scores were reported from silages obtained by mixing white clover with barley at 20%+80% [38], forage peas with barley at 25%+75% [37; 39], grasspea with triticale at 20%+80% [40], common vetch with oats at 25%+75% [41].

Table 2. Average scores and quality class of physical properties of silages of sole and binary mixtures of fenugreek, oat and rye

Applications	Odor	Structure	Color	DLG	Quality class
100% Oats	13.50	3.75	2.00	19.25	Very good
100% Rye	13.00	3.75	1.75	18.50	Very good
100% Fenugreek	9.50	2.50	1.30	13.30	Medium
75% Oats + 25% Fenugreek	14.00	3.75	2.00	19.75	Very good
50% Oats + 50% Fenugreek	13.75	4.00	1.65	19.40	Very good
25% Oats + 75% Fenugreek	11.50	3.50	1.65	16.65	Good
75% Rye + 25% Fenugreek	12.50	3.75	1.90	18.15	Very good
50% Rye + 50% Fenugreek	12.00	4.00	1.60	17.60	Good
25% Rye + 75% Fenugreek	10.75	3.50	1.65	15.90	Good
Mean	**12.28**	**3.61**	**1.72**	**17.61**	**Good**

3.2. Silage Dry Matter Ratio and Some Chemical Properties

The DM ratio and some chemical properties of silages obtained with different ratios of mixtures of fenugreek, oat and rye are given in Table 3. As can be seen from Table 3, the difference between the applications in terms of all silage quality parameters was found to be statistically significant at the $p<0.01$ level.

The DM ratio is of great importance in the complete realization of chemical events during silage formation, and this ratio is accepted as an important criteria in determining silage quality [42; 43]. In the study, the DM content varied between 15.67% (sole fenugreek)-34.33% (sole rye). It was determined that silage DM ratio increased in parallel with the increase in the ratio of oat and rye in the mixtures (Table 3). In general, DM contents of grass plants are higher than legumes [37]. This situation led to an increase in the DM ratio in silages obtained by adding cereals to fenugreek, which has a very low DM content. It was also been reported in many research findings that the silage DM ratio increases due to the increase in the cereal ratio in the mixture, and that quality silages were obtained in this sense [37-41; 44]. According to these results, sole silage of fenugreek will reduce silage quality. Therefore, there was a positive relationship between silage quality and DM ratio. Ensiling excessively high moisture content plant affects the lactic acid fermentation in the silo negatively and increases the formation of butter acid [45]. For this reason, the silage material must contain highly soluble carbohydrates per unit dry matter.

Table 3. DM ratio and some chemical properties of silages of sole and binary mixtures of fenugreek, oat and rye*

Application	DM (%)	pH	CP (%)	ADF (%)	NDF (%)	RFV
100% Oats	25.33 c	5.50 d	6.01 f	40.27 c	64.83 c	82.55 g
100% Rye	34.33 a	5.06 g	6.62 ef	48.90 a	74.53 a	63.41 i
100% Fenugreek	15.67 g	5.79 a	18.17 a	32.03 f	40.07 i	148.48 a
75% Oats + 25% Fenugreek	23.33 d	5.52 d	6.92 e	40.27 c	58.63 e	91.28 e
50% Oats + 50% Fenugreek	19.67 e	5.59 c	12.30 c	37.40 d	50.90 f	109.23 d
25% Oats + 75% Fenugreek	17.67 f	5.66 b	16.00 b	34.73 e	45.90 h	125.34 b
75% Rye + 25% Fenugreek	29.33 b	5.24 f	7.92 d	46.83 b	68.60 b	71.08 h
50% Rye + 50% Fenugreek	23.67 d	5.45 e	12.63 c	40.57 c	60.62 d	87.94 f
25% Rye + 75% Fenugreek	20.33 e	5.67 b	15.67 b	35.43 e	49.10 g	116.15 c
Mean	**23.26**	**5.50**	**11.36**	**39.60**	**57.02**	**99.50**

*: No significant difference at the $p\leq0.01$ level were determined between the means shown with the same letter.

Silage pH value is one of the main factors affecting the fermentation quality [46-49]. In our study, the highest pH was obtained from sole fenugreek (5.79), and the lowest was obtained from sole rye (5.06) silage (Table 3). It is reported that the silage pH level should be kept at low levels in order to obtain a quality silage [50], while Filya [47] stated that the pH value of a good silage should be below 5. Other researchers [51-54] reported that the pH value of a good silage was between 3.5 and 4.5. It was observed that the pH value was above the desired value in all silage applications examined according to these critical values in the literature. It is thought that this situation is probably due to the lack of good compaction in the silo. However, when Table 3 is examined, reductions in fenugreek ratio in mixtures resulted with reductions in pH values of silages. In other words, as the proportion of cereals included in the mixture increased, the pH value of the silage decreased (Table 3). It has been reported in some research results that the silage pH values of the silages consisting of a mixture of leguminous forage plants and some cereals differ according to the mixing ratios. Silage pH value according to the mixing ratio; was 5.05-5.34 according to Demirel et al. [38] in barley and white clover mixtures, 3.90-4.00 according to Aykan and Saruhan [37] and Seydoşoğlu [39] in barley and forage pea mixtures, 3.99-4.19 according to Karadeniz et al. [40] in mixtures of triticale and grasspea, 5.03-6.04 according to Görü and Seydoşoğlu [41] in mixtures of some cool season cereals (oat, barley, rye and triticale) and common vetch, 4.51-4.83 according to Gülümser et al. [44] in oat and forage pea mixtures.

Crude protein ratio is considered as an important indicator in determining the quality of forages. In the study, the highest CP rate was determined in sole fenugreek silage with 18.17%. The lowest CP ratio was found in sole oat silage (6.01%). It was observed that the CP values of the silages belonging to the cereal-fenugreek mixtures, where the ratio of silage of cereals and fenugreek was 25%, were in the low group statistically. In other words, silage CP values increased in parallel with the increase in the amount of fenugreek in the mixture (Table 3). This is due to the fact that fenugreek is a legume. In some other studies, in which CP ratios of silages increase with the increase in legume ratios in the mixtures [2; 41; 49; 55-57].

When the ADF and NDF ratios of the silages belonging to the sole and different mixtures of fenugreek, oat and rye are examined, the highest ADF and NDF ratio is sole rye (48.90% and 74.53%, respectively), and the lowest is sole fenugreek (32.03% and 40.07%, respectively) silages (Table 3). This is an expected result. Because the fiber density of leguminous plants is lower than that of grass [58]. In the study, it was also observed that the ADF and NDF contents of the silages obtained decreased as the amount of fenugreek added to the mixture increased (Table 3). This can be explained by the proportional decrease in cell wall substances in mixtures where fenugreek, which is rich in cellular substances such as CP, is a legume. In other words, the low ADF and NDF content of fenugreek was effective in the low ADF and NDF content of the silage it was mixed with. The ratio of ADF and NDF, which are plant cell wall components, is a good indicator of total digestible nutrients, and it is desirable to have a low ratio of ADF and NDF in roughage [59; 60]. As another result of our study, considering the ratio of ADF and NDF, it can be said that silages obtained from fenugreek-oat mixtures produced higher quality roughage than fenugreek-rye mixtures (Table 3). In silages made with different grass-legume mixtures, Can et al. [61] found the ADF ratio to be 29.61-35.88% and the NDF ratio to be 41.66-57.49% in tedera (*Bituminaria bituminosa* L.) and oat mixed silages; Turan [56] found the ADF ratio of 30.19%-33.11% and the NDF ratio to 43.00-47.84% in Hungarian vetch and barley mixtures; Karadeniz et al. [40] found the ADF ratio to be 32.76-34.63% and the NDF ratio to be 46.87-49.70% in the mixtures of grasspea and triticale; Görü and Seydoşoğlu [41] reported the ADF ratio between 31.85-42.99% and NDF ratio between 47.47-68.12% in some cool climate cereals (oat, barley, rye and triticale) and common vetch mixtures. In the same studies, the researchers reported that ADF and NDF ratios of silages decreased with the increase in legume ratios in the mixtures, consistent with the findings of our study.

The RFV of the silages ranged from 63.41 (sole rye) to 148.48 (sole fenugreek) (Table 3). When the RFV values determined in the study were evaluated according to the quality class determined by Rohweder et al. [35]; sole rye and 75% rye+25% fenugreek mixture silages were 5th class, sole oats silage were 4th class, 75% oats+25% fenugreek and 50% rye+50% fenugreek mixtures were 3rd class, 50% oats+50% fenugreek and 25 mixtures of % rye+75% fenugreek were produced 2nd class and sole fenugreek and 25% oats+75% fenugreek mixed silages were produced 1st class quality fodders. Accordingly, it was observed that higher quality silage was obtained as the ratio of fenugreek plant in the mixture increased (Table 3). Similar results were obtained in terms of RFV in silages consisting of legume-grass mixes [39; 41; 49; 56; 61].

4. CONCLUSION

In this study, in which the quality characteristics of the silages of different mixtures of fenugreek, oat and rye were determined, better results were obtained from the mixtures compared to the sole silages of the species. This shows that fenugreek mixed with cereals can be ensiled and it is a promising legume for silage production. According to these results, it was concluded that the silage of 25% oats + 75% fenugreek mixture was superior to the silage obtained from other mixtures, especially when considering the chemical parameters.

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