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Determination of The Effects on Silage Quality of Different Additives Added to Vetch-Triticale Silage Mixture

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A B S T R A C T

This research was conducted at Sakarya University of Applied Sciences, Faculty of Agriculture's Field Crops Laboratory. The aim of the study is to determine the effects of three different silage additives (molasses (M), whey (W), and citrus pulp (CiP)), added to pure and mixtures of common vetch (*Vicia sativa* L.)+triticale (*xTriticosecale* Wittmack) in different proportions on silage quality. The plant materials under investigation were mixed in ratios of 25%, 50%, 75% and 100%. Silages and mixtures were established with three replications, and three different silage additives were applied to each mixture. These additives included 4% molasses, 3% whey, and 2% citrus pulp. Silages were analyzed for crude protein (CrP), acid detergent fiber (ADF), neutral detergent fiber (NDF), dry matter (DM), pH, crude ash (CA), as well as phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) contents. Additionally, flieg score and physical analysis criteria (odor, color, and structure) were determined. Considering the interaction of silage mixture ratio and additive, statistically significant differences were observed among silages in parameters such as CP, K, P, and pH at a 1% level and among silages in parameters such as CA, ADF, NDF, Ca, Mg, and DM at a 5% level. As a result of the analysis, the the highest CP ratio was obtained with 17.51% from silage mixtures (75%V+25%T)+W additives, the highest ADF ratio was obtained with 40.81% from silage mixtures (50%V+50%T)+M additives, and the highest NDF ratio was obtained 57.46% from silage mixture (50%V+50%T)+CiP additives. According to physical analysis criteria; It was determined that silage quality varied between 3.75 and 18.25. In parallel with the increase in the vetch ratio in the silage mixture; It was determined that the contents of crude protein, crude ash, K, P, Mg, and Ca were positively affected, while the pH value was negatively affected. It was observed that the NDF content was low and the Mg content was high in the silages to which molasses was added. Consequently, it can be said that making silage in the form of a legume-cereal mixture rather than in pure form positively affects silage quality, and the addition of additives to mixed silages has a positive effect on silage quality.

1. Introduction

Agriculture has been of vital importance to humanity since its existence. Food production is a fundamental activity that supports the sustainability and well-being of societies (Hien et al., 2023). However, agriculture is not limited to the cultivation and harvesting of crops; the preservation and future usability of products also play a crucial role (Özdemir and Okumuş, 2022; Chao, 2023). For this reason, there is an increasing

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focus on silage applications for the optimal preservation of forage crops used in animal feeding. Silage is a method that allows the fermentation-based preservation and storage of fresh plant material. It is commonly produced from crops such as corn, sorghum, triticale, alfalfa, vetch, or other plants, providing a year-round accessible feed source for livestock such as cattle, sheep, goats, and other farm animals (Kung et al., 2018; Jaipolsaen et al., 2022). However, the benefits of silage extend beyond its use as animal feed, making it a foundation of modern agricultural practices. Among its advantages is its role in animal nutrition, providing high-quality and balanced nutrition for farm animals. This not only enhances the quality of animal products such as meat and milk but also improves animal health and productivity. Additionally, silage becomes crucial for sustaining animal nutrition during periods when fresh forage or feed sources are limited, especially in winter months. This ensures the continuous production of livestock for agricultural operations (Karadeniz, 2019). In addition to its nutritional importance, silage offers ease of preservation and storage. Silage serves as an excellent method for the long-term storage of plant material, minimizing product losses and providing farmers with greater economic security. Silage also has environmental significance, particularly in the reuse of by-products generated during silage production for biogas production or reuse as fertilizer, enhancing environmental sustainability. Silage requires less energy and water while facilitating the long-term preservation of products (Özhan, 2010). In this context, silage acts as a bridge between the sustainability and efficiency of modern agriculture.

Forage crops used in silage production can be categorized into three main groups: legumes, cereals, and other forage crops. Legume forage crops include plants like clover, vetch, forage peas, trefoil, and more, while cereal forage crops include corn, sorghum, triticale, oats, etc. (Tıknazoğlu, 2009). From a nutritional perspective, legume forage crops are rich in protein and fiber, while cereal forage crops are rich in carbohydrates. When silage is made from these crops in their pure form, they may lack certain nutrients. However, when mixed, they complement each other, leading to a more balanced animal diet. Mixed silage enhances nutritional balance and allows the simultaneous intake of various nutrients (Kavut and Geren, 2017). Moreover, Öten et al. (2016) stated in their study that making silage as a mixture of wheat forage crops and legume forage crops gives better results than making silage alone.

The leguminous forage crop common vetch (*Vicia sativa* L.), which is the subject of the study, is rich in carbohydrates (starch and sugars) and fibers, and it has a high protein content. In terms of vitamins, it is a good source of B vitamins (folate, thiamine, and B6) and vitamin C, and in terms of minerals, especially potassium, magnesium, iron, and zinc (Yalçın et al., 1998; Huang et al., 2017). Triticale (*xTriticosecale* Wittmack), a hybrid of wheat and rye in the grass forage crop group, generally contains a high amount of carbohydrates in the form of starch. Despite having a higher protein content compared to wheat and rye, it is not as rich in protein as legumes. Although it contains some fibers, it has a lower fiber content compared to legumes. In terms of vitamins, it is a rich source of B vitamins (thiamine, riboflavin, niacin) and may also include other vitamins such as folate and vitamin E. In terms of minerals, it is rich in certain minerals like magnesium, phosphorus, and iron (Yalchi et al., 2010; Mergoum et al., 2019; Kyrylchuk et al., 2023). Considering the information provided, when evaluating a ratio composed of common vetch and triticale together, triticale has a higher carbohydrate content, whereas common vetch has higher protein and fiber content. The mixtures of these plants are important for enhancing nutritional balance.

Numerous studies have been conducted on forage crops over the years, aiming to create rations by combining different variations of crops. These studies have identified the most effective combinations and their performances. Scientists have gone a step further, focusing on determining the ideal ratios for these combinations in silage production to achieve optimal performance.

In a study conducted to determine the most optimal mixture ratios of triticale and common vetch under Tunisian conditions (100%, 67-33%, 50-50%, 40-60%, 33-67%), the highest dry matter content was achieved in mixtures containing 67% common vetch and 33% triticale, as well as 50% common vetch and 50% triticale (Aziza et al., 2013). Yıldırım and Özaslan 2016), in their study aimed to determine the yield and yield components of triticale mixed with various legumes (faba bean, forage pea, and Hungarian vetch) in different ratios (pure, 75:25, 50:50, and 25:75), found that as the legume content in the mixture increased, the crude protein content also increased, and as the triticale content increased, the dry forage yield increased. They also reported that the neutral detergent fiber (NDF) content decreased in legumes sown in pure stands, but increased in mixtures containing 25% legumes.

Under non-ideal conditions for silage production, the quality and stability of silage can be compromised. Hence, various additives are used to improve silage preservation and quality (Muck et al., 2018). These additives accelerate the fermentation process, inhibit the growth of unwanted microorganisms, enhance nutrient content, and ensure long-term storage of silage.

The additives selected for this study (molasses, whey, and citrus pulp) are chosen from industrial by-products that stand out for their low cost, easy accessibility, environmental friendliness, and recyclability. Molasses is a dark brown syrup containing approximately 50% sugar, resulting from the gradual industrial processing of sugar beets. It shows an enhancing effect on the number and activity of *Lactobacillus* bacteria effective in lactic acid fermentation, inhibiting the development of unwanted microorganisms (Zi et al., 2022). Another additive, whey, is a by-product of the cheese-making process, rich in lactose. It has a pH-lowering effect and enhances lactic acid production, improving fermentation quality (Fallah, 2019). Citrus pulp is a by-product of the fruit squeezing process, typically rich in fiber, pectin, and other plant components. It may act as an aroma or fiber source in silage (Başar and Atalay, 2020; Souza et al., 2022).

This study aims to determine the effects of some silage additives (molasses, whey, and citrus pulp), added to vetch and triticale silage mixtures in different ratios, on silage quality.

2. Materials and Methods

2.1. Material

2.1.1. Plant Materials

In this study, the Alperen common vetch variety obtained from Trakya Agricultural Research Institute and the Okkan-54 registered triticale variety obtained from Sakarya Maize Research Institute were used as plant materials

2.1.2. Additive Materials

As silage additives added to the vetch-triticale silage mixture in this study, molasses obtained from Adapazarı Sugar Factory Inc., fresh whey from the Dairy Processing Facility of Sakarya University of Applied Sciences, Pamukova Vocational School, and citrus pulp (from lemon and orange) sourced from the market were used.

2.2. Method

The study was conducted with five different silage mixture ratios: 25% vetch + 75% triticale, 50% vetch + 50% triticale, 75% vetch + 25% triticale, 100% vetch, and 100% triticale. These mixture ratios were set up with three replications, and each mixture received three different silage additive applications. The additives included 4% molasses, 3% whey, and 2% citrus pulp.

Samples with added additives were filled into 2-liter plastic bags, compressed to eliminate air, and left for fermentation under laboratory conditions at 24 ± 4°C for 60 days. After the fermentation period, the pH analysis was performed using an electronically calibrated pH meter before other analyses. The dry matter (DM) content of the silage samples was determined by leaving the samples in an oven at 70°C for 48 hours. Subsequently, analyses were conducted to determine crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), crude ash (CA), and certain nutrient elements (phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg)). Additionally, physical analysis criteria such as odor, color, and structure were determined in the silage samples.

Dry matter, crude ash, and nutrient elements (P, K, Ca, and Mg) analyses were performed according to Uzun (2010). The Kjeldahl method was utilized for determining crude protein content (Akyıldız, 1984). ADF and NDF analyses were conducted based on the Van Soest method (Van Soest et al., 1991). Silage quality was determined using the Flieg point method developed by Kılıç (1986), based on the relationship between silage pH value and dry matter content. The Flieg point was calculated using the formula "Flieg point = 220 + (2 × Dry Matter Percentage - 15) - 40 × pH". Physical analyses to evaluate silage quality were performed using the scoring method developed by the German Agricultural Society (DLG) and the methods recommended by Alçiçek and Özkan (1997). Based on these analyses, scores were assigned for the color, odor, and structural characteristics of the silage, and these scores were classified according to Table 1.

Research data were subjected to analysis of variance using the SAS (1998) statistical package program according to the Randomized Complete Block Design (Düzgüneş et al., 1987). Differences between means were determined using the Duncan (1955) multiple comparison method.

Table 1. According to physical analysis criteria quality groups of silage

Score Range	Degree
18-20	Very Good (VG)
14-17	Good (G)
10-13	Medium (M)
5-9	Low (L)
0-4	Deteriorated (D)

3. Results and Discussion

The chemical contents of silages prepared by mixing vetch and triticale in ratios of 25%, 50%, and 75%, in addition to their plain silages, with the addition of whey (W), citrus pulp (CiP), and molasses (M) were determined. The obtained results are presented in Table 2.

When the crude protein content of silages is examined, it has been determined that silages of vetch prepared with additives in their pure form, to which whey and citrus pulp are added, have higher values. In triticale silages prepared in their pure form with additives, it has been observed that all added additives have lower values compared to other silages. In silages prepared with different mixing ratios and additives, the highest crude protein content was observed at 17.51% in the (75%V+25%T)+W silage mixture and 17.48% in the 100% V. The lowest crude protein content was found in the mixtures with 10.23%, 10.43%, and 10.47% in the ratios of 25%V+75%T with all types of additives. Since common vetch, a legume forage crop is rich in protein, an increase in its content in the mixtures increased crude protein content, and a decrease in its content led to a decrease in crude protein content. When evaluated based on the silage additives, whey, with a higher protein content, had a protein-enhancing effect in all mixing ratios. In comparison to previous studies, the mixtures of silages with additives align with Balabanlı et al. (2010) and are generally lower than Yıldırım and Özaslan Parlak (2016). Additionally, the results are consistent with 100%V and 50%V+50%T, higher than 25%V+75%T, and 75%V+25%T when compared to Önal Aşcı and Eğritaş (2017).

When the crude ash content of silage blends is examined, it has been determined that in vetch silages prepared in their pure form with additives, the silages with whey added have higher crude ash content, whereas in triticale silages prepared in their pure form with additives, the silages with molasses added have higher crude ash content. In silages prepared with different mixing ratios and additives the highest ash content was 17.45% in 100% V, and the lowest ash content was 5.05% in (25%V+75%T)+CiP silage mixture. The increase in the vetch ratio in the silages increased ash content. Eğritaş and Önal Aşçı (2015) determined that the average ash content in pure common vetch was 13.59%, in pure triticale was 7.95%, in the 25%V+75%T mixture was 6.30%, in the 50%V+50%T mixture was 5.95%, and in the 75%V+25%T mixture was 6.05%. Yıldırım and Özaslan Parlak (2016) reported that in pure Hungarian vetch, the ash content was 13.59%, in pure triticale was 9.40%, in the 25%V+75%T mixture was 11.83%, in the 50V+50T mixture was 12.38%, and in the 75%V+25%T mixture was 11.83%. When compared with the results of Eğritaş and Önal Aşçı (2015), it was found that the pure triticale and 25%V+75%T additive mixtures were consistent, while the pure common vetch, 50%V+50%T, and 75%V+25%T additive silage mixtures were higher. In comparison with Yıldırım and Özaslan Parlak (2016), it was observed that the ash content of additive pure silages and the 50%V+50%T additive silage mixture was consistent, the 25%V+75%T and additive silage mixtures were lower, and the 75%V+25%T additive silage mixtures were higher.

Table 2. The effects of additives on crude protein and crude ash values of vetch-triticale silage mixtures

Mixing Ratios	Crude Protein (%)			Crude Ash (%)		
	Molasses	Citrus pulp	Whey	Molasses	Citrus pulp	Whey
25% V+75% T	10.43f	10.23f	10.47f	8.79j	5.05m	7.83k
50% V+50% T	12.07e	12.37e	12.26e	13.56e	10.23h	11.66fg
75% V+25% T	15.91d	16.78bc	17.51a	11.89f	15.12c	17.01b
100% V	16.50cd	17.20ab	17.48a	11.47g	14.55d	17.45a
100% T	10.42f	10.09f	10.49f	9.18ı	6.86l	7.55k
Significance	*			**		
CV	3.14			2.04		
LSD	0.1652			0.6624		

The acid detergent fiber (ADF) value has been found to be higher in silages of pure vetch with the addition of molasses and in silages of pure triticale with the addition of whey (Table 3). When examining mixed silages, the highest ADF ratio was 40.81% in (50%V+50%T)+M, and the lowest ADF ratio was 33.80% in 100%T. When analyzed by silage additives, the addition of citrus pulp, which increases the fiber content, reduced the ADF ratio in all mixing ratios. Balabanlı et al. (2010) reported an ADF ratio of 35.14% in a common vetch and triticale silage mixture. Yıldırım and Özaslan Parlak (2016) found ADF ratios of 30.94% in pure Hungarian vetch, 29.59% in pure triticale, 30.15% in 25%V+75%T mixture, 30.44% in 50%V+50%T mixture, and 30.39% in 75%V+25%T mixture. Önal Aşcı and Eğritaş (2017) determined ADF ratios of 34.40% in pure vetch, 37.36% in pure triticale, 36.40% in 25%V+75%T mixture, 37.15% in 50%V+50%T mixture, and 36.01% in 75%V+25%T mixture. The obtained results are consistent with the studies of Balabanlı et al. (2010) and Önal Aşcı and Eğritaş (2017) but are higher than Yıldırım and Özaslan Parlak (2016).

Table 3. Effects of additives on silage ADF and NDF contents in vetch-triticale mixture silages

Mixing Ratios	ADF(%)			NDF(%)		
	Molasses	Citrus pulp	Whey	Molasses	Citrus pulp	Whey
25% V+75% T	36.52fg	34.45hı	39.05bc	51.13ef	53.29cd	55.60b
50% V+50% T	40.81a	38.06d	38.26cd	50.98ef	54.35bc	57.46a
75% V+25% T	39.51b	36.18g	38.24cd	40.97h	51.47ef	53.55cd
100% V	37.93de	35.10h	36.96eg	41.43h	51.50ef	53.86cd
100% T	36.23g	33.80ı	37.30df	48.83g	50.30fg	52.56de
Significance		**			**	
CV		1.56			1.99	
LSD		0.4416			1.3524	

When examining the NDF (Neutral Detergent Fiber) content of silages, it has been determined that it is higher in silages of pure vetch and pure triticale with the addition of whey (Table 3). In mixed silages with additives, the highest NDF ratio was 57.46% with (50%V+50%T)+W, and the lowest were 40.97% with (75%V+25%T)+M and 100% V. Among the additives added to silages, whey showed an increasing effect on the NDF ratio in all mixing ratios, while molasses showed a decreasing effect on the NDF ratio in all mixtures. Balabanlı et al. (2010) reported an NDF ratio of 53.97% in a common vetch and triticale silage mixture. Yıldırım and Parlak (2016) stated ratios of 49.88% in pure Hungarian vetch, 55.53% in pure triticale, 53.72% in 25%V+75%T mixture, 50.98% in 50%V+50%T mixture, and 52.58% in 75%V+25%T mixture. Önal Aşcı and Eğritaş (2017) determined NDF ratios of 56.76% in pure vetch, 61.49% in pure triticale, 59.58% in 25%V+75%T mixture, 62.39% in 50%V+50%T mixture, and 59.87% in 75%V+25%T mixture. The obtained results are consistent with the studies of Balabanlı et al. (2010) and Yıldırım and Özaslan Parlak (2016) but lower than Önal Aşcı and Eğritaş (2017).

When evaluated in terms of mixing ratios, the highest Ca content were 1.21% with (75%V+25%T)+M and 1.15 with 100% V. The lowest Ca content were 0.39% with (25%V+75%T)+M and (25%V+75%T)+W silage additive mixtures (Table 4). The calcium (Ca) content has been found to be higher in silages of pure vetch with the addition of citrus pulp and in silages of pure triticale with the addition of both citrus pulp and whey. Eğritaş and Önal Aşçı (2015) determined Ca values as 4.45% in pure common vetch, 0.38% in pure triticale, 2.17% in the 25%V+75%T mixture, 2.41% in the 50%V+50%T mixture, and 2.64% in the 75%V+25%T mixture. The results obtained are consistent with pure triticale but lower than the other mixing ratios.

The potassium (K) content was found to be higher in silages where citrus pulp and whey were added as additives to pure vetch, and in silages where molasses and whey were added as additives to pure triticale (Table 4). In silages prepared from mixtures with different ratios and additives, the highest potassium (K) content were obtained from the silages with compositions (75%V+25%T)+W, (75%V+25%T)+CiP, (50%V+50%T)+W, (75%V+25%T)+M, and with values of 4.96%, 4.87%, 4.71%, 4.68%, 100% V+ CiP and 100% V+ W respectively. The lowest K content was found in silage 100% T+ CiP. Additionally, (25%V+75%T)+W and (25%V+75%T)+CiP had low K content with values of 3.85% and 3.58%, respectively. Eğritaş and Önal Aşçı (2015) determined the average K values in their two-year study as 1.36% in pure common vetch, 0.50% in pure triticale, 1.04% in the 25%V+75%T mixture, 0.99% in the 50%V+50%T mixture, and 1.10% in the 75%V+25%T mixture. The results obtained in this study were found to be higher than those of Eğritaş and Önal Aşçı (2015).

Table 4. Effects of additives on silage Ca and K contents in vetch-triticale mixture silages

Mixing Ratios	Ca(%)			K(%)		
	Molasses	Citrus pulp	Whey	Molasses	Citrus pulp	Whey
25% V+75% T	0.39g	0.44fg	0.39g	3.95de	3.58ef	3.85ef
50% V+50% T	0.86cd	0.79d	0.62e	4.07cd	4.44bc	4.71ab
75% V+25% T	1.21a	1.03b	0.87c	4.68ab	4.87a	4.96a
100% V	1.05b	1.15a	0.92c	4.45bc	4.81ab	4.80ab
100% T	0.40g	0.48f	0.42fg	3.91de	3.50f	3.70df
Significance		**			*	
CV		5.7			5.67	
LSD		0.0276			0.27	

As seen in Table 5, the highest Mg value was obtained from pure triticale (0.32%). On the other hand, in mixed silages, the highest value was obtained from (75%V+25%T)+M (0.32%). The lowest Mg value was 0.08% in the (25%V+75%T)+CiP mixture. The magnesium (Mg) content has been found to be higher in silages of pure vetch with the addition of molasses and in silages of pure triticale with the addition of citrus pulp. In the experiment, the highest P content was detected in (75%V+25%T)+W mixture with 0.44% (75%V+25%T)+W mixture and the lowest was 100% T+M.

Table 5. The effects of additives on Mg and P contents of vetch-triticale silage mixtures

Mixing Ratios	Mg(%)			P(%)		
	Molasses	Citrus pulp	Whey	Molasses	Citrus pulp	Whey
25% V+75% T	0.16fg	0.08j	0.10ıj	0.35fg	0.35gh	0.37cf
50% V+50% T	0.21d	0.19df	0.14gh	0.36dg	0.39c	0.38cd
75% V+25% T	0.32b	0.25c	0.20de	0.37cf	0.38ce	0.44a
100% V	0.33b	0.27c	0.25c	0.37cg	0.37cf	0.41b
100% T	0.17ef	0.63a	0.11hı	0.33h	0.36eg	0.38cd
Significance		**			*	
CV		5.59			3.63	
LSD		0.0165			0.0571	

Eğritaş and Önal Aşçı (2015) found Mg contents as 0.48% in pure vetch, 0.15% in pure triticale, 0.30% in the 25%V+75%T mixture, 0.31% in the 50%V+50%T mixture, and 0.32% in the 75%V+25%T mixture. They determined the P content as 1.11% in pure vetch, 0.29% in pure triticale, 0.39% in the 25%V+75%T mixture, 0.40% in the 50%V+50%T mixture, and 0.45% in the 75%V+25%T mixture. Ordinary vetches, rich in minerals such as K, Ca, Mg, and P, increased the content of these substances in the silages as their proportion in the mixture increased. Regarding the addition of additives, whey showed a phosphorus-increasing effect in all mixture ratios. When compared with the results of Eğritaş and Önal Aşçı (2015), it was observed that in terms of Mg, the silages with 75V+25T additives were consistent, pure vetch and mixtures with 25%V+75%T and 50%V+50%T additives had lower content, while pure triticale silages had higher content. For phosphorus, it was noted that the pure vetch silage had lower content, silage mixtures with additives of pure triticale and 25%V+75%T had higher content, and the other silages were similar.

According to Table 6, the dry matter content of silage mixtures with additives varied between

16.66% and 42.30%. The dry matter content has been found to be higher in silages of pure vetch with the addition of whey and in silages of pure triticale with the addition of citrus pulp. Among silages with different mixing ratios, the highest dry matter content was 42.00% with (25%V+75%T)+CiP, while the lowest was in silages 26.00% with (75%V+25%T)+M. The results are in line with the findings of Balabanlı et al. (2010), who reported a dry matter content of 34% in a mixture of common vetch and triticale silage.

Table 6. The effects of additives on dry matter and pH values of vetch-triticale silage mixtures

Mixing Ratios	Dry matter(%)			pH		
	Molasses	Citrus pulp	Whey	Molasses	Citrus pulp	Whey
25% V+75% T	33.00d	42.00a	39.00b	3.87ef	3.77ef	3.84ef
50% V+50% T	35.00c	28.00fg	33.00d	4.09de	4.45cd	4.58c
75% V+25% T	26.00h	28.33f	29.00f	4.71bc	5.10ab	5.41a
100% V	26.66gh	16.66ı	30.66e	4.43cd	4.81bc	5.36a
100% T	35.33c	42.30a	28.33f	3.80ef	3.62f	3.93ef
Significance		**			*	
CV		2.04			5.43	
LSD		0.24			0.0530	

The pH values have been found to be higher in silages of pure vetch with the addition of whey and in silages of pure triticale with the addition of molasses and whey. The highest pH values, 5.41 and 5.10, were obtained from silages with different mixture ratios containing additives, specifically (75%V+25%T)+W and (75%V+25%T)+CiP, respectively. The lowest pH, on the other hand, was obtained from all additive derivatives added to the mixture with a ratio of 25%V+75%T, with values of 3.77, 3.84, and 3.87. The increase in the proportion of common vetch in the mixture had an increasing effect on pH. Additionally, the addition of whey as an additive increased the pH in all mixing ratios. Balabanlı et al. (2010) reported a pH value of 5.22 in a mixture of common vetch and triticale silage. The results obtained are lower than those reported by Balabanlı et al. (2010) except for silage mixtures with a high proportion of common vetch.

The Flieg Scores calculated based on the formula "Flieg Score = 220 + (2 x DM%) - 40 x pH content" for silage mixtures with added additives are provided in Table 7.

The average Flieg scores determined range from 45.9 to 144.8. According to the evaluation based on Flieg scores, silage mixtures of (75%V+25%T)+CiP, (75%V+25%T)+W, (100%V)+CiP, and (100%V)+W are considered satisfactory, while the (75%V+25%T)+M silage mixture falls into the good category. All other additive mixtures have been classified as excellent. Alçiçek et al. (1999) evaluated vetch-barley mixtures collected from silos in different regions using the Flieg scoring system, and they rated them as good and moderate with scores of 84 and 37, respectively, on a scale of 100. Balabanlı et al. (2010) determined a Flieg score of 64.40 out of 100 for vetch-triticale silage mixtures and classified it as "good." The results obtained are consistent with the studies of Balabanlı et al. (2010) and Alçiçek et al. (1999) in terms of dry matter content, Flieg score, and evaluation.

Table 7. Flieg points for common vetch-triticale silage mixtures with added additives

Mixing Ratios	Silages	Score	Assessment
25% V+75%	CiP	138.2	Very Good
25% V+75%	M	116.2	Very Good
25% V+75%	W	129.2	Very Good
50% V+50%	CiP	82.8	Very Good
50% V+50%	M	111.4	Very Good
50% V+50%	W	87.6	Very Good
75% V+25%	CiP	57.6	Satisfactory
75% V+25%	M	68.4	Good
75% V+25%	W	46.4	Satisfactory
100% V	CiP	45.9	Satisfactory
100% T	CiP	144.8	Very Good
100% V	M	81.0	Very Good
100% T	M	123.4	Very Good
100%V	W	51.6	Satisfactory
100% T	W	104.3	Very Good

M: Molasses, CiP: Citrus Pulp, W: Whey

The scores and evaluations obtained from the physical analysis criteria are presented in Table 8. As seen in the table, the average scores of the physical analysis results range from 3.75 to 18.25. The silage mixture (100%V)+CiP received a score of 3.75 in the physical analysis evaluation, indicating spoilage. On the other hand, the silage mixtures (100%T)+W and (25%V+75%T)+W obtained scores of 18.25 and 17.56, respectively, indicating excellent results. It is observed that the proportion of triticale in the mixture increases, the quality of the silage improves, and the application of whey positively influences the silage. Alçiçek et al. (1999) evaluated vetch-barley mixtures collected from silos in different regions as excellent and satisfactory. Demirel et al. (2001) assessed all silage mixtures as satisfactory based on the physical analysis results when mixing Hungarian vetch and sorghum in different proportions. Balabanlı et al. (2010) rated the physical analysis results of vetch-triticale silage mixtures as excellent with a score of 17.5. The results obtained in this study are consistent with other studies.

Table 8. Physical analysis results of common vetch triticale silage mixtures with added additives

Mixing Ratios+Silage	Score	Assessment
(25% V+75% T)+W	17.56	Very Good
(50% V+50% T)+W	15.50	Good
(75% V+25% T)+W	12.18	Medium
(25% V+75% T)+CiP	15.62	Good
(50% V+50% T)+CiP	13.81	Good
(75% V+25% T)+CiP	13.31	Medium
(25% V+75% T)+M	15.06	Good
(50% V+50% T)+M	16.68	Good
(75% V+25% T)+M	9.81	Medium
(100% V)+W	6.52	Low
(100% V)+CiP	3.75	Deteriorated
(100% V)+M	8.42	Low
(100% T)+W	18.25	Very Good
(100% T)+CiP	16.85	Good
(100% T)+M	12.59	Medium

According to these evaluations based on physical data, silo feeds; 18-20 points = Very Good, 14-17 points = Good, 10-13 points = Medium, 5-9 points = Low, 0-4 points = Deteriorated

Ülger et al. (2015) conducted a study to determine the effect of different fruit pulps added to sugar beet pulp on silage quality. They reported that apple and orange pulps could be effective in obtaining high-quality silage. Acar and Bostan (2016) found in their study, which aimed to investigate the effect of barley bran, molasses, and whey powder additives added to clover silage, that only whey powder had a higher pH content compared to the control group. Overall, they determined that the added additives improved the forage quality. Gülümser et al. (2019) observed significant effects of molasses and barley bran additives, added in different ratios to soybean and cowpea silages, on dry matter content and pH parameters, indicating an improvement in silage quality, especially with the cowpea+10% molasses mixture.

4. Conclusions

An ideal silage mixture is expected to have a high crude protein content, low ADF and NDF ratios, high crude ash content, richness in nutrients, high dry matter, low pH, and a high Flieg score. In this context, the data obtained in the study are evaluated in three groups: chemical content, Flieg point, and physical analysis criteria. When evaluated in terms of chemical content, it was determined that the addition of citrus pulp and whey to vetch silage and the addition of molasses and citrus pulp to triticale enriched the silage compared to the control group, which consisted of plain silages. In mixtures, it was found that (75%V+25%T)+M and (75%V+25%T)+W were more suitable than other mixtures. When evaluated according to the Flieg score, (25%V+75%T)+CiP, (25%V+75%T)+M, (25%V+75%T)+W, (50%V+50%T)+CiP, (50%V+50%T)+M, (50%V+50%T)+W silage mixtures with the addition rated as very good. However, silage mixtures with the addition of 50% vetch and 50% triticale with molasses, citrus pulp, and triticale-protein mix rated as good. The dry matter content was lower in mixtures with 75% vetch, resulting in lower Flieg scores. Physically and sensorially analyzed criteria (odor, color, and structure) highlighted silage mixtures with the addition (25%V+75%T)+W and (100%T)+W. While chemical content showed positive results in mixtures with an increased vetch ratio, parallel increases in Flieg scores and physical analysis results were observed in a negative direction. In this study, Flieg point and physical analysis results for silage mixtures (25%V+75% T)+W were found similar.

As the vetch ratio increased in silage mixtures, crude protein, crude ash, K, P, Mg, and Ca content also increased. However, an increase in the vetch ratio led to an increase in pH. In silages with molasses as an additive, it was found that the NDF ratio was lower, and the Mg content was higher. The silage mixture with (50%V+50%T)+M had a higher ADF ratio than plain triticale silage. Silages with citrus pulp as an additive had a lower ADF ratio. In silages with whey as an additive, crude protein, P, NDF, and pH contents were higher, while Ca content was lower.

Based on these results, it can be concluded that making silage mixtures with legumes and cereals, rather than making silage from each individually, positively affects silage quality. The addition of additives to silage mixtures enhances silage quality. Also, it is suggested that evaluating physical-sensory analyses and Flieg points together with chemical content values would provide a more accurate assessment in determining silage quality.

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