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Forage Yield of Foxtail Millet (*Setaria italica* (L.) P. Beauvois) and Its Some Quality and Nutritional Values of Fodder and Silages Obtained from Different Morphological Parts and Silages with Alfalfa (*Medicago sativa* L.)

Gülcan DEMİROĞLU TOPÇU [1*], Sebahattin BOYACI [1], Hazım Serkan TENİKECİER [2], Ertan ATEŞ [2]

[1]*Field Crops Department, Faculty of Agriculture, Ege University, 35040 Izmir, Türkiye*
[2]*Field Crops Department, Faculty of Agriculture, Tekirdag Namik Kemal University, 59030 Tekirdag, Türkiye*

✉ *Corresponding author: gulcan.demiroglu.topcu@ege.edu.tr*

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ABSTRACT

The research was carried out in the 2022 and 2023 summer growing seasons in Muğla province, which is under the influence of the Coastal Mediterranean Climate, according to the randomized complete block design with three replications. The 2022 and 2023 summer growing seasons to determine the forage yield of foxtail millet and some of its nutritional values of its fodder and silages, obtained from different morphological parts and in combination with alfalfa. The fresh fodder yield (t ha^{-1}), dry fodder yield (t ha^{-1}), crude ash ratio (%) crude protein ratio (%), dry matter ratio (%), ADF (%), NDF (%), digestible dry matter (DDM, %), dry matter intake (DMI, %), total digestible nutrients (TDN, %), net energy-lactation (Nel, Mcal lb^{-1}), net energy-maintenance (NEm, Mcal lb^{-1}), net energy-gain (Neg, Mcal lb^{-1}), relative feed value (RFV, %), pH, fleig score were determined from dry fodder, silage and foxtail millet-alfalfa silages. The characteristics which were examined in the study determined statistically significant at $P<0.01$. Fresh fodder yield and dry fodder yields were varied between 14.50-20.95 t ha^{-1} and 4.71-7.31 t ha^{-1} respectively. The highest crude protein ratio (16.76%), dry matter ratio (42.06%), crude ash ratio (7.83%), DDM (67.95%), DMI (2.71%), TDN (65.42%), NEl (0.68 Mcal lb^{-1}), NEm (0.73 Mcal lb^{-1}) NEg (0.40 Mcal lb^{-1}), RFV (142.92%) and the lowest ADF (26.89%) and NDF (44.23%) were determined from spike of foxtail millets's dry fodder. The highest crude protein (14.82%) was determined in silage from leaf, the lowest ADF (38.80%) and NDF (54.76%), the highest TDN (51.73%), DDM (58.67%), DMI (2.20%), Nel (0.52 Mcal lb^{-1}), NEm (0.55 Mcal lb^{-1}) and RFV (100.49%) were determined in silage from spike, the highest dry matter ratio (92.61%) was determined in stem, the lowest pH (4.56, 4.93 and 5.92) and the highest flieg score (207.06, 192.53 and 186.49) were determined in whole plant, leaf and spike of foxtail millet silages. The highest crude protein (22.92%), dry matter ratio (93.13%), TDN (60.15%), DDM (64.62%), DMI (2.48%), Nel (0.62 Mcal lb^{-1}), NEm (0.66 Mcal lb^{-1}) and RFV (124.42), the lowest ADF and NDF (31.71% and 48.33%) were determined in %100 alfalfa silage. The highest fleig score (215.27) was determined in 75% Seteria + 25% Alfalfa silage. It can be concluded that; the foxtail millet hay is seen to be sufficient on its own when evaluated in terms of some forage quality aspects and nutritional value. Foxtail millet can be ensiled into reasonable silage, but the quality can be improved with the addition of alfalfa or different legumes or other protein sources.

1. INTRODUCTION

The foundation of a sustainable livestock forage system is built upon perennial legumes and grasses, which are integrated within crop rotation systems as well as natural hayfields and pastures (Kosolapov et al., 2015). Beyond natural pastures and rangelands, another significant source of roughage is forage crops cultivated on agricultural land. This source plays a critical role, particularly in meeting the demand for roughage when grazing on pasture and rangeland areas is not feasible during the winter, warm-season crops are cultivated to produce hay and silage to ensure the nutritional requirements of livestock are met. Supplementary feed sources play a crucial role in enhancing the productivity of cattle, swine, and poultry. These additional nutritional inputs are crucial for meeting the animals' elevated energy and nutrient requirements, thereby optimizing growth rates, reproduction, and overall performance in livestock production systems (Kosolapov et al., 2014).

Summer annual grasses hold significant value for livestock producers due to their rapid growth, high forage yield, and potential to provide excellent forage quality when harvested at the optimal growth stage. Key species among these grasses include *Sorghum* spp., *Sorghum* × *drummondii* (sudangrass), and several millets such as pearl millet (*Pennisetum glaucum*), browntop millet (*Urochloa ramosa*), foxtail millet (*Setaria italica* (L.) P. Beauvois), and Japanese millet (*Echinochloa esculenta*). Notably, German millet and Hungarian millet are recognized varieties of foxtail millet (*Setaria italica* (L.) P. Beauvois) (Baltensperger, 2001).

Foxtail millet (*Setaria italica* (L.) P. Beauvois), a member of the genus *Setaria* within the *Paniceae* tribe, comprises approximately 125 species, primarily distributed in tropical Africa, with a smaller presence in temperate regions (Genckan, 1983). This species is an annual, warm-season grass, with its natural range in China, and is considered one of the oldest cultivated crops globally (Skerman & Riveros, 1990). The grains of *S. italica* (L.) P. Beauvois have been utilized as a staple food in China, Egypt, and India for centuries (Ghimire et al., 2019). In Eastern European countries, the grains are processed into porridge, bread, and used in beer production. Approximately 85% of foxtail millet grain production is allocated for human consumption, while 6% is used as poultry feed. Moreover, the species is cultivated for hay and silage production (Hatipoglu & Tukel, 2009). Foxtail millet, in particular, is well-adapted to drought conditions due to its rapid growth rate and high adaptability to tropical climates. Additionally, it offers a high protein content and is characterized by its leafy and multi-stemmed structure, which allows regrowth after grazing or cutting. Regarding biomass production, foxtail millet can achieve yields comparable to maize (*Zea mays* L.), requiring approximately 60% of the water needed by corn. These summer annual grasses are versatile and can be utilized for grazing, hay, silage, or green chop production. For ensiling purposes, millet should be harvested at the mid-dough stage for optimal preservation and quality (Hamilton et al., 1978).

The study aimed to determine the forage yield of foxtail millet and some quality and nutritional values of fodder and silages obtained from different morphological parts and silages with alfalfa (*Medicago sativa* L.).

2. MATERIALS AND METHODS

The research was conducted at Karabaglar neighborhood, Mentese District, Mugla, Türkiye, with three replications in randomized complete block design, in 2022 and 2023 summer growing season. The soil properties of the study were given in Table 1.

Table 1. Soil properties of the study area[1].

Paramaeters	
pH	7.50
EC (ds/m)	0.260
Lime (%)	12.71
Organic Matter (%)	2.18
Total Nitrogen (%)	0.112
Phosphorus (P, mg kg^{-1})	41.40
Potassium (K, mg kg^{-1})	120.30
Calcium (Ca, mg kg^{-1})	4172.20
Magnesium (Mg, mg kg^{-1})	240.80
Iron (Fe mg kg^{-1})	14.73
Copper (Cu, mg kg^{-1})	2.10
Zinc (Zn, mg kg^{-1})	2.61
Manganese (Mn, mg kg^{-1})	1.75

[1] The analyses were performed in Ege University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition Laboratory.

Table 2. Climatic conditions of the study area[1]

Months	Total Precipitation (mm)			Mean Temperature (°C)			Relative Humidity (%)		
	2022	2023	Long-Term[2]	2022	2023	Long-Term[2]	2022	2023	Long-Term[2]
May	9.90	136.50	51.40	19.10	16.20	17.70	53.90	74.70	62.30
June	42.40	23.20	36.70	23.20	21.60	22.80	34.50	66.50	52.40
July	-	2.00	14.10	28.00	28.60	26.40	40.40	34.10	45.80
August	9.40	-	12.70	26.10	27.30	26.30	38.40	50.50	47.80
Mean		-	-	24.10	23.40	23.30	41.80	56.40	52.10
Total	61.70	161.70	114.90	-	-	-		-	-

[1]The data retrieved from Turkish State, Meteorological Service. [2]Long-Term covers the period between 1927-2021.

Some meteorological data of the experimental area during the vegetation period are presented in Table 2. The study area has a Mediterranean climate, with environmental and soil characteristics suitable for drought-resistant crops such as millet. During the summer, temperatures typically exceed 30°C, which aligns well with the optimal growth range of millet (25–30°C). In the summer, temperatures usually exceed 30°C, which is quite suitable for the optimal growth temperatures of millet, which are 25-30°C. The total precipitation of the experimental area was 61.7 mm in 2022 and 161.7 mm in 2023, mean temperature of 24.1 °C in 2022 and 23.4 °C in 2023, 41.8% in 2022 and 56.4% in 2023 relative humidity and between May and August of the study years. The total precipitation, mean temperature and relative humidity 52.1% in long term of the experimental area was 114.9 mm and 23.3 °C between May and September of the study years respectively.

Foxtail millet population obtained from Karabağlar neighborhood, Menteşe District, Muğla, Türkiye, was used as seed material. Seeds were sown in 8 rows with 5 m long plots by hand with 0.60 m inter-row space at 5.0 kg ha^{-1} seeding rate on 10.05.2022 and 10.6.2023. The second year's sowing was delayed due to metrological and soil conditions. Fertilization was done in the experimental plots as 250 kg N, 100 kg P_2O_5 and 100 kg K_2O per hectare. Half of the nitrogen and all of the phosphorus and potassium were applied to the base at planting, and the other half of the nitrogen was applied between the rows when the plants reached 20-25 cm in height. It has been observed that when regular irrigation is done every week, the plant grows an average of 40 cm in height. Before the plant starts to produce spikes (after about the 7th week), it has been observed that when 250 kg ha^{-1} of urea fertilizer is given with irrigation water, the growth in spike length increases. The last irrigation is done when the spikes turn about 50% ripening. The foxtail millet plots were harvested at milk dough ripening stage. The alfalfa samples were obtained from Ege University, Faculty of Agriculture, Field Crops Department Experimental Area, Izmir, Türkiye, at 10% flowering stage for silage mixtures. After the harvest of the foxtail millet, plants were separated to spike, leaf, stem and hole-plant to determine fresh fodder yield (t ha^{-1}), dry fodder yield (t ha^{-1}), crude protein (CP) ratio (%), dry matter (DM) ratio (%), crude ash (CA) ratio (%), ADF (%), NDF (%), digestible dry matter (DDM, %), dry matter intake (DMI, %), total digestible nutrients (TDN, %), net energy-lactation (Nel, Mcal lb^{-1}), net energy-maintenance (NEm, Mcal lb^{-1}), net energy-gain (Neg, Mcal lb^{-1}), relative feed value (RFV, %), pH, fleig score from dry fodder, silage and foxtail millet-alfalfa silages. Plants were harvested (foxtail millet: at full-ripening stage; alfalfa: at 10% flowering stage) by hand by cutting at soil level and left to wither for 2 hours. Withered plants were chopped to about 1-2 cm in size and the chopped materials were thoroughly mixed to attain homogeneity (Demiroglu Topçu & Kahya, 2023). Different mixture ratios (foxtail millet%-alfalfa %; 100-0, 75-25, 50-50, 25-75, 0-100; on the basis of fresh weight) were used for preparing the silage in four replications with a randomized plot design. Samples without additives of each foxtail millet-alfalfa silage mixture, standalone foxtail millet and different parts of foxtail millet (500±20 g) were placed in separate vacuum bags (thickness 110 microns or more), and after 99.9% of the air was removed by vacuum, bags were glued and closed (Johnson et al., 2005). The bagged silage samples were stored in a dark and cool environment at 24±4°C for 60 days. Oven drying for feed analysis at temperatures above 60°C can result in, heat damaged protein and elevated fiber and lignin values (Reed & Van Soest, 1984). For this reason, samples (both fresh fodder and silage) were dried at 60 °C for 48 hours followed by storage for a further day at room temperature, ground to small (≤1 mm) pieces and used for the analyses (Ates & Tenikecier, 2022a; Tenikecier & Ates, 2022). The samples were analyzed for N using procedures of the Association of Official Analytical Chemists (AOAC, 2019). Crude protein (CP) ratio (%) of the samples were calculated by multiplying N contents by a coefficient of 6.25. They dried in a forced-air oven at 60°C to a constant weight to determine the dry matter (DM) ratio (%) (Pereira et al., 2019). Crude ash (CA) ratio (%), acid detergent fiber (ADF, %), neutral detergent fiber (NDF, %) contents were determined by Weende and Van Soest methods (AOAC, 2019; Van Soest et al., 1991). The digestible dry matter (DDM, %), dry matter intake (DMI, %), relative feed value (RFV, %), total digestible nutrients (TDN, %), net energy for lactation (Nel, Mcal lb^{-1}), net energy for maintenance (NEm, Mcal lb^{-1}), and net energy for gain (Neg, Mcal lb^{-1}) were calculated using established equations for forage evaluation (Schroeder, 1994). The pH of the silages was measured using a pH meter. Fleig score was calculated using the formula suggested by Kılıç (1986).

Statistical analysis was performed using the TARIST (Acikgoz et al., 2004) statistical software package, and Fisher's Least Significant Difference (LSD) test was used for post hoc comparisons (Duzgunes et al., 1987), implemented with MSTAT-C software.

3. RESULTS AND DISCUSSION

Forage Yield

Fresh and dry fodder yields were varied between 14.50-20.95 t ha^{-1} and 4.71-7.31 t ha^{-1} respectively (Figure 1.). Dagtekin et al. (2020) determined herbage yield between 279.8-662.6 g plant^{-1} and hay yield between 84.6-145.3 g plant^{-1} respectively. Mohajer et al. (2011) determined hay yield between 4.80-11.80 t ha^{-1} and herbage yield between 19.30-37.00 t ha^{-1}. Mohajer et al. (2013) determined fresh yield between 22.83-34.00 t ha^{-1} and dry matter yield between 6.23-8.23 t ha^{-1}. Olak & Tan (2016) determined hay yield between 2.47-6.98 t ha^{-1}. Nematpour et al. (2020) determined hay yield 5.43 t ha^{-1}. Lu et al. (2024) determined the total weight at flowering stage 16.00 g plant^{-1}. The fresh and dry fodder yields were determined lower than those researchers.

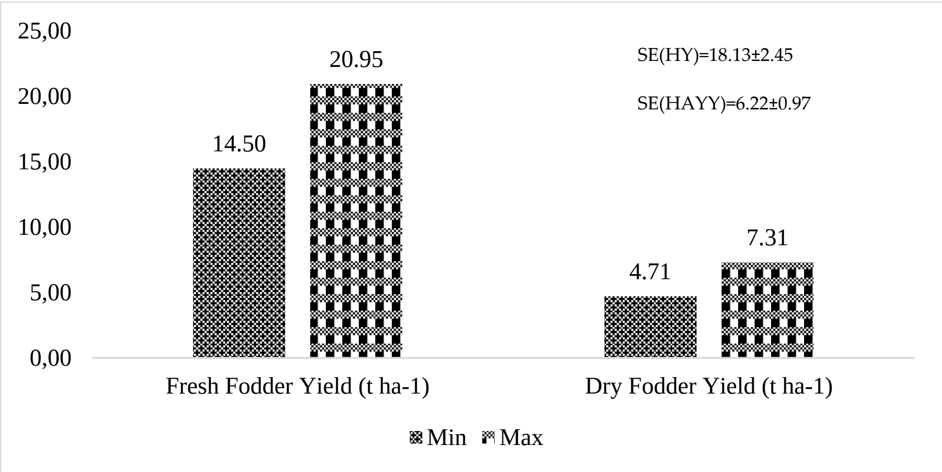

Figure 1. Fresh and dry fodder yield of foxtail millet.

Nutritional and Quality Properties of Different Morphological Parts and The Whole Plant of Foxtail Millet

The results of some nutritional and quality traits of dried different morphological parts and the whole plant of foxtail millet are given in Table 3. Crude protein ratio (%), dry matter ratio (%), crude ash ratio (%), ADF (%), NDF (%), DDM (%), DMI (%), TDN (%), NEl (Mcal lb^{-1}), NEm (Mcal lb^{-1}), NEg (Mcal lb^{-1}) and RFV (%) means of dried some morphological parts and the whole plant of foxtail millet were determined statistically significant at P<0.01.

Table 3. Some nutritional and quality aspects of dried different morphological parts and the whole plant of foxtail millet.

Characteristics	Spike	Leaf	Stem	Whole plant	*Mean*	LSD$^{¥}$
Crude Protein Ratio (%)	16.76a	12.40c	9.65d	15.18b	*13.50*	0.993**
Dry Matter Ratio (%)	42.06a	25.69d	38.45b	34.23c	*35.11*	3.502**
Crude Ash Ratio (%)	5.34b	4.15c	2.63d	7.83a	*4.99*	0.747**
ADF (%)	26.89c	36.90b	47.33a	36.77b	*36.97*	2.754**
NDF (%)	44.23c	57.03b	67.57a	60.46b	*57.35*	3.593**
DDM (%)	67.95a	60.16b	52.03c	60.26b	*60.10*	2.142**
DMI (%)	2.71a	2.11b	1.78c	1.99b	*2.15*	0.138**
TDN (%)	65.42a	53.92b	41.92c	54.07b	*53.83*	3.164**
Nel (Mcal lb^{-1})	0.68a	0.55b	0.41c	0.55b	*0.55*	0.043**
NEm (Mcal lb^{-1})	0.73a	0.58b	0.42c	0.58b	*0.58*	0.041**
Neg (Mcal lb^{-1})	0.40a	0.25b	0.09c	0.25b	*0.25*	0.042**
RFV (%)	142.92a	98.16b	71.59d	92.74c	*101.35*	4.362**

a-d: The difference between groups containing different letters in the same row is statistically significant, $^{¥}$: **: P<0.01

The highest crude protein (16.76%), dry matter ratio (42.06%), DDM (67.95%), DMI (2.71%), TDN (65.42%), NEl (0.68 Mcal lb^{-1}), NEm (0.73 Mcal lb^{-1}) NEg (0.40 Mcal lb^{-1}), RFV (142.92%) and the lowest ADF (26.89%) and NDF (44.23%) were determined from spike of foxtail millet respectively. The highest crude ash (7.83%) was determined from foxtail millet whole-plant (Table 3). Arbabi & Ghoorchi (2008) determined dry matter 303 g kg^{-1}, crude protein 105.3 g kg^{-1}, ADF 334.1 g kg^{-1}, NDF 547.2 g kg^{-1}, DDM 629 g kg^{-1} and TDN 613.1 g kg^{-1} respectively. Mohajer et al. (2011) determined crude protein ratio 5.3-11.3%, digestibility 56.2-69.7, ADF 26.2-35.3% respectively. Dastenal et al. (2012) determined ADF between 31.2-32.0 %. Mohajer et al., (2013) determined crude protein between 7.80-11.66%, crude fiber between 39.48-39.67%, ADF between 29.3-31.29% and ash between 7.49-18% respectively. Heuzé et al. (2015) determined crude protein ratio between 8.3-12.5%, ADF 33.4-43.8 %, NDF 48.4- 72.0 % respectively. Olak & Tan (2016) determined crude protein ratio between 11.97-14.04 %, ADF 34.95-39.33, NDF 56.13-64.71 respectively. Peiretti & Tassone (2016) determined dry matter 299 g kg^{-1}, crude ash 110 g kg^{-1}, crude protein 55.3 g kg^{-1}, ADF 421 g kg^{-1} and NDF 674 g kg^{-1} respectively. Dagtekin et al. (2020) determined crude protein ratio 10.3-15.6%, ADF 39.8-49.8, NDF 74.9-85.6 respectively. The results of the study were determined similar to mentioned above researchers. Rohweder et al. (1978) determined the limit values of quality standards according to crude protein, ADF and NDF ratios of forages. They report that the relative feed value is considered 83-100 when the ADF and NDF ratios are between 39-41% and 61-65% respectively, and if the RFV is greater than 151, the feed is the best quality for grass hays. The RFV values of the spike and leaf of foxtail millet and whole plant shows enough potential for good forage quality.

Nutritional and Quality Characteristics of Silage from Different Morphological Parts and Whole Plant of Foxtail Millet

The results of some nutritional and quality characteristics of silage from different morphological parts and the whole plant of foxtail millet are given in Table 4. Crude protein ratio (%), dry matter ratio (%), ADF (%), NDF (%), DDM (%), DMI (%), TDN (%), NEl (Mcal lb^{-1}), NEm (Mcal lb^{-1}), pH and Fleig score and RFV (%) means of silages from different morphological parts and the whole plant of foxtail millet were determined statistically significant at $P<0.01$.

Table 4. Some nutritional and quality aspects of silage from some parts of foxtail millet

Characteristics	**Spike**	**Leaf**	**Stem**	**Whole-Plant**	***Mean***	**LSD¥**
Crude Protein Ratio (%)	11.62c	14.82a	12.78b	13.28b	*13.12*	1.12**
Dry Matter Ratio (%)	92.48b	92.30c	92.61a	92.23c	*92.40*	0.10**
ADF (%)	38.80c	48.40b	48.55b	53.09a	*47.21*	4.48**
NDF (%)	54.67b	66.50a	64.92a	63.77a	*62.46*	7.01**
TDN (%)	51.73a	40.69b	40.52b	35.29c	*42.06*	5.15**
DDM (%)	58.67a	51.20b	51.08b	47.54c	*52.12*	3.49**
DMI (%)	2.20a	1.80b	1.85b	1.88b	*1.93*	0.26**
NEl (Mcal lb^{-1})	0.52a	0.40b	0.39b	0.34b	*0.41*	0.06**
NEm (Mcal lb^{-1})	0.55a	0.41b	0.40b	0.33c	*0.42*	0.07**
pH	5.09b	4.93b	6.27a	4.56b	*5.21*	1.00**
Fleig Score	186.49a	192.53a	139.29b	207.06a	*181.34*	39.87**
RFV (%)	100.49a	71.62b	73.25b	69.36b	*78.68*	17.29**

a-c: The difference between groups containing different letters in the same row is statistically significant, ¥: **: $P<0.01$

The highest crude protein (14.82%) was determined in silage from leaf, the lowest ADF (38.80%) and NDF (54.76%), the highest TDN (51.73%), DDM (58.67%), DMI (2.20%), Nel (0.52 Mcal lb^{-1}), NEm (0.55 Mcal lb^{-1}) and RFV (100.49%) were determined in silage from spike, the highest dry matter ratio (92.61%) was determined in stem, the lowest pH (4.56, 4.93 and 5.92) and the highest Flieg score (207.06, 192.53 and 186.49) were determined in silages from whole plant, leaf and spike of foxtail millet (Table 4.). Arbabi & Ghoorchi (2008) determined pH 4.88, crude protein 108.00 g kg^{-1}, ADF 495.80 g kg^{-1}, NDF 612.60 g kg^{-1}, DDM 609.70 g kg^{-1} and TDN 579.80 g kg^{-1} respectively. Peiretti & Tassone (2016) determined dry matter 470 g kg^{-1}, crude protein g kg^{-1} 52.6 g kg^{-1}, ADF 407 g kg^{-1}, NDF 644 g kg^{-1}, pH 4.76 respectively. Nematpour et al. (2020) determined silage dry matter content 318 g kg^{-1}, crude protein 143 g kg^{-1}, ADF 308 g kg^{-1}, NDF 584 g kg^{-1}, pH 4.65, DDM 649 g kg^{-1}, NEL 1.49 Mcal kg^{-1} and RFV 104 g kg^{-1} respectively. The results of the study were determined similar to those researchers. Karaer et al. (2024) determined pH of the sorghum × Sudan grass hybrid silages between 4.40-4.79. Silage quality is classified based on Fleig scores as follows: very good for Fleig scores of 85–100; good for Fleig scores of 60–84; moderate for Fleig scores of 40–59; satisfactory for Fleig scores of 20–39; worthless for Fleig scores of <20 (Kilic, 1986). When the Fleig score of the silage from different part of foxtail millet examined, it can be declared that the foxtail millet can be ensiled appropriately. The RFV were determined between 69.36%-100.49% in silage from different parts of foxtail millet. When the RFV which were declared by Rohweder et al. (1978) for grass hays, enough potential for good forage quality was determined in the RFV of the silage from spike (100.19%) of foxtail millet.

Nutritional and Quality Aspects of Foxtail Millet+Alfalfa Silages

The results of some forage and nutritional quality of foxtail millet+alfalfa silages are given in Table 5.

Table 5. Some nutritional and quality aspects of foxtail millet+alfalfa silages

Characteristics	**100% Foxtail Millet**	**100% Alfalfa**	**75% Foxtail Millet + 25% Alfalfa**	**50% Foxtail Millet + 50% Alfalfa**	**25% Foxtail Millet + 75% Alfalfa**	***Mean***	**LSD[¥]**
Crude Protein Ratio (%)	13.28d	22.92a	14.70c	15.53c	17.75b	*16.84*	1.33**
Dry Matter Ratio (%)	92.23b	93.13a	91.87b	91.89b	92.20b	*92.26*	0.81**
ADF (%)	53.09a	31.17b	53.64a	53.78a	53.32a	*49.00*	2.82**
NDF (%)	63.77b	48.33c	66.70a	65.50ab	63.45b	*61.55*	2.50**
TDN (%)	35.29b	60.51a	34.67b	34.50b	35.04b	*40.00*	3.24**
DDM (%)	47.54b	64.62a	47.12b	47.00b	47.36b	*50.73*	2.20**
DMI (%)	1.88b	2.48a	1.80b	1.83b	1.89b	*1.98*	0.10**
NEl (Mcal lb^{-1})	0.34b	0.62a	0.33b	0.33b	0.34b	*0.39*	0.03**
NEm (Mcal lb^{-1})	0.33b	0.66a	0.33b	0.32b	0.33b	*0.39*	0.04**
pH	4.56ab	4.73a	4.34c	4.43bc	4.76a	*4.56*	0.20**
Fleig Score	207.06c	202.19d	215.27a	211.57b	199.01e	*207.02*	2.10**
RFV (%)	69.36b	124.42a	65.72b	66.76b	69.45b	*79.14*	4.48**

a-d: The difference between groups containing different letters in the same row is statistically significant, ¥: **: P<0.01

Crude protein ratio (%), dry matter ratio (%), ADF (%), NDF (%), DDM (%), DMI (%), TDN (%), NEl (Mcal lb-1), NEm (Mcal lb-1), pH and fleig score and RFV (%) means of foxtail millet+alfalfa silages were determined statistically significant at P<0.01. The highest crude protein (22.92%), dry matter ratio (93.13%), TDN (60.15%), DDM (64.62%), DMI (2.48%), Nel (0.62 Mcal lb^{-1}), NEm (0.66 Mcal lb^{-1}) and RFV (124.42%), the lowest ADF and NDF (31.71% and 48.33%) were determined in %100 alfalfa silage. The highest Fleig score (215.27) was determined in 75% Seteria + 25% alfalfa silage (Table 5.). Ozturk et al. (2006) determined DM between 20.44-28.78%, CP 7.93-19.25%, NDF between 43.27-45.43, ADF between 23.90-34.56%, pH 3.13-5.43 and Fleig score between 13.67-108.89 of alfalfa+maize silages at different ratios (100, 70:30, 55:45, 40:60, 25:75). Zhang et al. (2017) determined the CP between 87.30-172 g kg^{-1}, NDF between 449-459 g kg^{-1} and ADF between 247-257 g kg^{-1} of alfalfa+maize silages at different ratios (100, 80:20, 60:40, 40:60, 20:80). The results were determined similar to Ozturk et al. (2006), Arbabi & Ghoorchi (2008), Peiretti & Tassone (2016), Zhang et al. (2017) and Nematpour et al. (2020). When the pH values were examined, the pH value observed in the inoculant-free alfalfa silage was surprising despite its high protein content. However, a literature review revealed that similar values for alfalfa, fodder pea (*Pisum arvense* L.) and Persian clover (*Trifolium resupinatum* L.) were also reported by Adiyaman et al. (2014), Tao et al. (2017), Ates & Tenikecier (2022b) and Tenikecier & Ates (2024). The Fleig scores of the foxtail millet+alfalfa silages were determined similar to Karaer et al. (2024) and Kılıç (1986). According to Fleig score of the foxtail millet+alfalfa silages, it can be concluded that the silage from foxtail millet and alfalfa has appropriate ensiling capacity. Rohweder et al. (1978) determined the limit values of quality standards according to crude protein, ADF and NDF ratios of forages. They report that the relative feed value is considered 100 when the ADF and NDF ratios are 41% and 53% respectively, and if the RFV is greater than 151, the feed is the best quality in alfalfa. According to RFV of the foxtail millet silage and silage mixture with alfalfa has enough forage quality.

A 500 kg beef cattle (*Bos taurus* L.) with superior milking ability, nursing a calf during the first 3 to 4 months postpartum, requires a minimum of 28.6 Mcal of digestible energy (NRC, 2001). These energy demands can be met with approximately 11.8 kg of DM intake per day from forage sources (Essig, 1985). Daily digestible DM intake has a stronger correlation with total DM intake than with DM digestibility. In most forage crops, cell wall constituents typically make up 55-85% of the DM content, and these components are influenced by numerous factors (Tenikecier & Ates, 2018). DM serves as a crucial indicator of the quantity of nutrients available to the animal in a given feed source, directly impacting nutritional efficiency and feed quality. To digest cellulose and hemicellulose, which are classified as water-insoluble carbohydrates found in plant cell walls, ruminant animals break down the cell wall through physical mastication during rumination, followed by slow fermentation facilitated by cellulolytic bacteria in the rumen. Feed intake is influenced by the high fiber content in roughages, as these fibers occupy space in the rumen for extended periods, slowing digestion. The ADF content in forage plants is a key indicator of feed quality; thus, knowing the ADF ratio is essential prior to ration formulation. Additionally, the NDF value of forage grasses provides insight into the bulkiness of the grass. A higher NDF value indicates that the forage has a larger volume, which can affect feed intake and digestion dynamics (Atalay & Ates, 2020). The nutrition quality of the forages shows considerable differences depending on different places and times (Stodart et al., 1975). Olak & Tan (2016) identified foxtail millet as a warm-season species. Consequently, these plants demonstrate rapid growth and development due to their high photosynthetic efficiency. However, this characteristic can negatively impact their nutrient composition and feed value. Warm-season species typically have lower crude protein content and higher concentrations of structural fibers such as ADF and NDF, which can reduce their overall nutritional quality as forage. It is thought that the differences between the study results and previous foxtail millet studies are due to ecological conditions, cultivation techniques and harvest time.

4. CONCLUSIONS

It can be concluded that foxtail millet hay is adequate on its own in terms of certain forage quality parameters and nutritional value. However, our research found that adding alfalfa to foxtail millet silage influenced both the crude protein content—crucial for animal nutrition—and the Fleig score, a key indicator of silage quality. Overall, while foxtail millet can be ensiled into reasonably good-quality silage by itself, its quality can be further enhanced with the addition of alfalfa, other legumes, or alternative protein sources.

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