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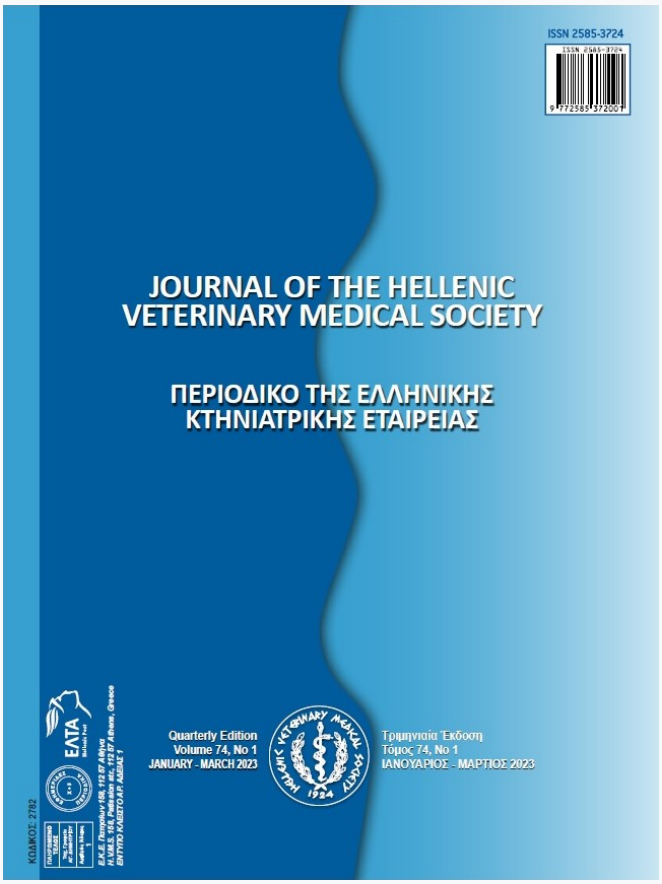

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Evaluation of Some Roughages for Ruminant Nutrition

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ABSTRACT: The present study was conducted to determine the feed value of different roughage sources cultivated in 186 different locations in the Western Mediterranean region of Türkiye. The materials of the study were 11 different roughage sources (Legume and Grass Forages) or their mixtures collected from the 27 districts of Antalya (8), Isparta (10) and Burdur (9) provinces representing the region. 45 legume samples (alfalfa hay (37) and vetch stalk (8) 109 grasses samples (barley stalk (28), wheat fodder (2), wheat stalk (49), oat stalk (12) and grass hay (18); 32 mixture samples (barley-oat stalk (11), barley-wheat stalk (5), barley-vetch stalk (13) and vetch-oat stalk (3) were used for determination of their nutrient contents, feed, and energy values.

The relative feed value (RFV) and the relative forage quality (RFQ) results of all roughages; vetch stalk 102.42 & 113.69, alfalfa hay 99.17 & 112.41 for legumes; among the wheats; grass hay 99.50 & 113.05, oat stalk 80.84 & 84.27, wheat fodder 78.69 & 83.83, barley stalk 67.72 & 69.45, wheat stalk 48.88 & 56.97 and mixed roughages were determined as vetch-oat stalk 100.49 & 108.18, barley-vetch stalk 92.58 & 97.14, barley-oat stalk 93.21 & 92.93and barley-wheat stalk 81.97 & 81.36.

Grass hay, vetch stalk and vetch-oat stalk were determined as the third quality roughage according to the RFV. These results might have been due to the wrong harvesting time and harvests made with inappropriate equipment; serious nutrient losses occur in roughages until they reached the animal's feed. According to RFQ; grass hay, vetch stalk and alfalfa hay should be used in feeding heifer, 12 to 18 months beef cow-calf, while vetch-oat stalk is in the class of roughage should be used in feeding of heifer and cows in dry season. Nutrient analysis of roughage samples showed that the nutritional losses could have occurred during harvesting and post harvesting transportation, attributing to wrong harvesting time, inappropriate harvesting equipment, and transportation to farms.

Keywords: Alfalfa hay, barley stalk, oat stalk, vetch stalk, wheat stalk.

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INTRODUCTION

The imbalances in income distribution around the world cause some countries to struggle with obesity and starvation. The same effect has been seen on agricultural production models. Manufacturers are forced to meet the nutritional substances needs of a rapidly growing population, while the largest share of this negativity has been belonged particularly to livestock sector in Türkiye. Because, although ruminants (cattle, sheep and goat) are based on pasture lands in general, these areas have become unable to meet the needs of animal production due to excessive grazing (Oğuz et al. 2013), being used for different purposes or insufficient care in management (Bıçakçı and Açıkbaş, 2018). For this reason, the share of areas where roughage crops will be cultivated in agricultural production models are expected to increase as parallel with the human population, but on the contrary, it is decreasing. Roughage plants, which are of great importance to ensure rumination in ruminant animals, are highly affected by this situation. The habit of using the residues or wastes left after the products produced by traditional methods by farmers a roughage source in livestock prevents an effective animal feeding (Açıkbaş and Özyazıcı, 2019).

Roughage crops gain the quality of stalk or straw until they come in front of animals due to unconscious production and handling methods, which should be grown as dry grass (Öten et al. 2018). Forage losses in plants were evaluated in 5 different categories. These; 1) loss of plant respiration; 2) rain damage; 3) loss from machinery; 4) straw storage loss and 5) silo storage loss (Rotz and Muck, 1994). Post-harvest losses in plants occurred as leaves, water-soluble carbohydrates, or protein losses. Livestock enterprises always ignore these losses when feeding animals. Accordingly, it causes losses in feed quality and nutrient content (Moser, 1980). Since the animals cannot reach the right roughage plants at the rate of their needs, their yield share decreases, and mortalities can be seen because of metabolic disorders such as acidosis and ketosis.Generally, roughage crops are classified into three groups as legumes,grasses, and legume and grass mixtures (Rotz, 1995). According to their grain content, legumes have a high-crude protein value, and grass have high-energy values. Roughages can be planted separately as well as in the form of legume-grass mix roughages in different proportions. In addition, roughages contain important nutrient differences depending on factors such as climate, variety, soil, fertilization, harvesting methods and consequently post-harvest handling, including transportation. For this reason, there has been no study that determines the nutrient contents of roughages belonging to ecological regions or countries during conventional handling process till reaching feeders. Up to now, the nutrient contents of roughages have been included in the literature as the figures represented by samples taken from very limited areas or from a few farms. Therefore, in the present study, the nutrient contents of the roughages collected from a wide area of different districts of Antalya, Burdur and Isparta provinces were determined within the scope of the Western Mediterranean Region of Türkiye to fill the gap in the literature. In general, studies are field studies aimed at measuring the adaptation abilities of plants and/or determining their nutrient content. However, in the current study, the results of the roughage samples taken from the places where the final consumer animals were stocked before consumption were evaluated.

MATERIAL AND METHOD

Türkiye is one of the countries lying in the east of the Mediterranean region of Europe. The Mediterranean region, located in the south of Türkiye, is divided to east and west region. The Western Mediterranean Region-Türkiye has an area of 36.797 km^2 including Antalya, Burdur and Isparta provinces (BAKA, 2013). Roughage samples from Antalya (8), Isparta (10) and Burdur (9) provincial centers and 24 districts of these provinces, from 186 different locations in total between May-October 2013, as Karabulut and Canbolat (2005) stated, collected from wholesalers or livestock farms as it was either solely or mixture. Forage samples were collected from 186 different locations from 27 different regions due to the large number of microclimatic features in the Western Mediterranean Region of Türkiye (Figure 1).

The main material of the study consists of 11 different roughages. Legumes: alfalfa hay (37), vetch stalk (8); wheats: barley stalk (28), wheat fodder (2), wheat stalk (49), oat stalk (12), grass hay (18) and mixture roughages: barley-oat stalk (11), barley-wheat stalk (5), barley-vetch stalk (13) and vetch-oat stalk (3). Nutritional analysis of the samples of roughages taken from four different points of the sample area were carried out in the Akdeniz University, Feed and Animal Nutrition Laboratory. Nutrient analysis (dry matter, organic matter, crude protein, ether extract, ash, ADF, NDF, ADL and crude fiber) and the ADFom, NDFom, hemicellulose, cellulose, total carbohydrates, non-fiber carbohydrates, nitrogen-free

extracts, total digestible nutrient, and energy values calculated using the results of this analysis were made according to AOAC (2000), Van Soest et al. (1991), AOCS (2005) and Sniffen et al. (1992). The RFV and RFQ were determined respectively by the methods of Rohweder et al. (1978) and Undersander and Moore (2002) (Table 1). Data were analysed GLM procedure of SPSS (2008-Windows version of SPSS, release 17.0, SPSS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

The present study was conducted to determine the nutrient content of 11 different roughages grown in 186 different locations in the Western Mediterranean Region, Türkiye. These roughages include alfalfa hay and vetch stalk as legumes and barley straw, wheat fodder, wheat straw, oat hay and grass hay as grasses or their mixed. In 2020, the production amounts of legumes and grasses in the Western Mediterranean Region of Türkiye were 324.210, 142.064, 288.338, 14.123, 471.787, 80.366 and 138 tons, respectively (TÜİK, 2021).

Since the relative feed value (RFV) and the relative forage quality (RFQ) were calculated from all nutrient analyzes, these parameters were considered important for animal nutrition. Therefore, RFV and RFQ results of all roughages; vetch stalk 102.42 & 113.69, alfalfa hay 99.17 & 112.41 for legumes; among the wheats; grass hay 99.50 & 113.05, oat stalk 80.84 & 84.27, wheat fodder 78.69 & 83.83, barley stalk 67.72 & 69.45, wheat stalk 48.88 & 56.97 and roughage mixtures were determined as vetch-oat stalk 100.49 & 108.18, barley-vetch stalk 92.58 & 97.14, barley-oat stalk 93.21 & 92.93 and barley-wheat stalk 81.97 & 81.36. The other nutritional parameters are given in Table 2 and 3.

Dry matter contents of legumes, grasses and their mixtures were found to be quite high. The reason for this has been that the plants were either over-dried or dried in the place where they were kept, due to excessive heat. Because the regions where the samples were taken are inland, and instead of the high humidity and temperatures that are characteristic of the Western Mediterranean Region, it is a region with

Figure 1. Western Mediterranean Region of Türkiye

Table 1. RFV and RFQ classification scale

RFV Score	**> 151**	**125–151**	**103–124**	**87–102**	**75–86**	**(<75)**
Quality	The best	The prime	The second	The third	The fourth	The fifth-poor quality to be rejected
RFQ Score	**140–160**	**125–150**		**115–130**		**100–200**
Type of animal	Dairy, 1st trimester Dairy calf	Dairy, last 200 days Heifer, 3 to 12 months Stocker cattle		Heifer, 12 to 18 months Beef cow-calf		Heifer are described as 18 to 24 months Dry cow

Table 2. Nutritional contents of some roughages

Roughages	Legume		Grass				Mixed				
Location	**37**	**8**	**28**	**2**	**49**	**12**	**18**	**11**	**5**	**13**	**3**
Parameters	**Alfalfa Hay**	**Vetch Stalk**	**Barley Stalk**	**Wheat Fodder**	**Wheat Stalk**	**Oat Stalk**	**Grass Hay**	**Barley-Oat Stalk**	**Barley-Wheat Stalk**	**Barley-Vetch Stalk**	**Vetch-Oat Stalk**
DM [1]	920.81±0.88	917.14±3.10	941.37±1.38	933.30±4.70	944.26±1.39	937.43±1.71	923.58±1.82	936.06±1.59	939.87±3.63	927.30±3.11	929.52±4.66
OM [2]	88.94±0.17	91.00±0.77	83.20±0.32	93.10±0.38	94.11±0.14	92.64±0.49	91.63±0.30	94.30±0.14	94.82±0.22	92.85±0.35	92.28±0.61
CP [2]	14.78±0.55	11.85±2.08	3.20±0.33	9.25±0.14	2.72±0.25	8.93±0.85	12.80±0.92	8.68±0.56	7.16±1.54	10.62±0.80	13.69±0.32
EE [2]	1.06±0.09	1.89±0.23	0.93±0.09	1.49±0.49	0.95±0.07	1.63±0.28	2.51±0.17	2.41±0.28	1.24±0.25	1.83±0.11	1.86±0.25
Ash [2]	11.06±0.17	9.00±0.77	5.43±0.15	6.90±0.38	5.89±0.14	7.37±0.49	8.37±0.30	5.70±0.14	5.18±0.22	7.15±0.35	7.72±0.61
ADF [2]	38.27±0.68	39.93±2.29	46.93±1.23	40.70±0.05	56.08±0.86	39.65±1.45	40.74±1.00	36.54±1.45	38.68±3.47	37.58±1.60	35.45±0.78
ADF_{om} [3]	27.21±0.75	30.93±2.96	41.50±1.18	33.80±0.43	50.19±0.82	32.29±1.72	32.37±1.21	30.84±1.43	33.50±3.51	30.43±1.67	27.73±1.28
NDF [2]	56.77±1.25	55.81±4.53	74.02±1.64	67.64±1.41	88.25±1.25	67.35±1.39	57.97±2.99	61.96±2.79	69.94±6.20	61.46±2.36	57.27±3.83
NDF_{om} [3]	45.71±1.32	46.80±5.25	68.59±1.59	60.74±1.03	82.36±1.23	59.98±1.65	49.60±3.25	56.26±2.76	64.76±6.20	54.31±2.60	49.55±4.44
ADL [2]	10.14±0.28	12.74±0.86	15.03±0.57	11.24±0.38	18.51±0.40	10.93±0.64	12.84±0.34	10.62±0.61	10.66±1.46	11.10±0.83	9.68±0.34
CF [2]	27.18±0.53	26.13±1.55	30.96±0.75	25.61±0.41	36.52±0.51	27.77±0.96	26.83±0.87	24.87±0.91	26.97±2.07	25.42±0.84	24.72±0.67
HCel[2]	18.49±0.71	15.87±2.42	27.09±0.87	26.94±1.46	32.17±0.63	27.69±0.65	18.61±1.84	25.41±1.59	31.26±3.06	23.88±1.90	21.82±3.27
Cel[2]	28.13±0.53	27.20±1.55	31.89±0.75	28.66±0.41	37.57±0.51	28.73±0.96	27.90±0.86	25.93±0.91	28.02±2.07	26.48±0.83	25.77±0.66
TC [1]	73.10±0.66	77.26±2.79	90.45±0.39	82.37±0.04	90.44±0.32	82.07±0.98	76.32±1.26	83.21±0.67	86.42±1.88	80.40±1.13	76.73±0.85
NFC [1]	16.33±0.81	21.46±1.88	16.43±1.38	14.73±1.45	6.00±1.44	14.73±0.91	18.35±2.05	21.25±2.28	16.48±4.85	18.93±1.63	19.46±3.04
NFE [1]	38.00±0.36	42.85±1.74	53.62±0.54	48.10±0.02	48.34±0.51	48.04±0.69	41.85±0.79	51.94±0.55	53.43±0.80	47.71±1.30	44.96±0.76

[1] g/kg of natural material; [2] (%) of dry matter; **DM**: Dry Matter (g/kg), **OM**: Organic Matter (%), **CP**: Crude Protein (%), **EE**: Ether Extract (%), **Ash** (%), **ADF**: Acid Detergent Fiber (%) ; [3]**ADF_{om}**=ADF−ash, **NDF**: Neutral Detergent Fiber (%), **NDF_{om}**=NDF−ash, **ADL**: Acid Detergent Lignin (%), **CF**: Crude Fiber (%), **HCel**: Hemicellulose (%), **Cel**: Cellulose (%), **TC**: Total Carbohydrates (g/kg), **NFC**: Non-Fiber Carbohydrates (g/kg), **NFE**: Nitrogen Free Extracts (g/kg).

Table 3. Energy and Nutritive values of some roughages

Roughages	Legume		Grass				Mixed				
Location	**37**	**8**	**28**	**2**	**49**	**12**	**18**	**11**	**5**	**13**	**3**
Parameters	**Alfalfa Hay**	**Vetch Stalk**	**Barley Stalk**	**Wheat Fodder**	**Wheat Stalk**	**Oat Stalk**	**Grass Hay**	**Barley-Oat Stalk**	**Barley-Wheat Stalk**	**Barley-Vetch Stalk**	**Vetch -Oat Stalk**
DE	2.82±0.03	2.69±0.10	2.27±0.02	2.57±0.00	2.23±0.01	2.55±0.04	2.73±0.04	2.54±0.03	2.47±0.08	2.63±0.04	2.77±0.02
ME	2.31±0.02	2.20±0.08	1.86±0.01	2.10±0.00	1.83±0.01	2.09±0.03	2.24±0.04	2.08±0.02	2.02±0.06	2.16±0.03	2.27±0.01
NE_L	0.66±0.01	0.63±0.03	0.52±0.00	0.59±0.00	0.51±0.00	0.59±0.01	0.64±0.01	1.29±0.02	0.57±0.02	0.61±0.01	0.65±0.00
NE_m	1.44±0.02	1.34±0.08	1.02±0.01	1.25±0.01	0.99±0.01	1.23±0.03	1.37±0.03	1.23±0.02	1.17±0.06	1.30±0.03	1.40±0.01
NE_g	0.85±0.02	0.76±0.07	0.47±0.01	0.68±0.01	0.44±0.01	0.67±0.03	0.79±0.03	0.67±0.02	0.61±0.05	0.73±0.03	0.82±0.01
TDN [2]	63.88±0.60	60.90±2.26	51.57±0.39	58.10±0.12	50.69±0.28	57.75±0.94	61.84±1.01	57.69±0.63	55.97±1.73	59.68±0.86	62.92±0.38
DDM	59.09±0.53	57.79±1.78	52.34±0.96	57.19±0.04	45.21±0.67	58.01±1.13	57.16±0.78	60.43±1.13	58.77±2.70	59.62±1.25	61.29±0.61
DMI	2.15±0.05	2.25±0.18	1.65±0.05	1.78±0.04	1.38±0.03	1.79±0.04	2.21±0.18	1.98±0.09	1.77±0.16	1.99±0.09	2.11±0.14
RFV	99.17±3.03	102.42±11.01	67.72±3.46	78.69±1.59	48.88±1.97	80.84±3.22	99.50±9.54	93.21±5.61	81.97±10.73	92.58±5.32	100.49±7.12
RFQ	112.41±3.42	113.69±13.22	69.45±2.56	83.83±1.59	56.97±1.44	84.27±2.89	113.05±11.01	92.93±4.75	81.36±9.34	97.14±5.37	108.18±7.53

DDM: Digestible Dry Matter (%), **DMI:** Dry Matter Intake (Live Weight: LW, %), **RFV**: Relative Feed Value and **RFQ**: Relative Forage Quality, **DE**: Digestible Energy (MJ/kg), **NE_L**: Net Energy-Lactation (MJ/kg), **NE_m**: Net Energy-Maintenance (MJ/kg), **NE_g**: Net Energy-Gain (MJ/kg), and **TDN**: Total Digestible Nutrient (%).

low humidity, high temperature and wind intense. For this reason, plants that are sufficiently dried and transported in the field are exposed to an extra dry air in the area where they are stored. In addition, since Burdur is a province where intensive dairy cattle breeding is carried out, some breeder farms in this region stock roughage crops in large haylages to minimize losses (Rotz and Muck, 1994). In the provinces of Isparta and Antalya, the nutritional losses caused by the breeding conditions are ignored by the breeders due to the intense amount of goat and sheep breeding. It can be speculated that these losses might come from the samples which were excessively dry and shedding leaves during transporting to feed boxes. For this reason, losses occurring during the period from harvest time, post-harvest transportation and storage or from storage to feed boxes are extremely important in terms of animal nutrition. Öten and Albayrak (2018) determined that the average CP % value of alfalfa hay, they collected from Antalya province and its districts, were higher than the current study results, but on the contrary, they determined the ADF and NDF % value to be low (15.38%, 36.72 and 47.23, respectively). Due to the high moisture content of Antalya

province, it is thought to be caused by the lack of leaf shedding, especially due to dry air. The results given in Tables 2 and 3 collected from 37 different locations were compared with the results of CP, ADF, NDF, TDN % and RFV (respectively 19.6, 65.1 and 145.4) of alfalfa hay collected from the lakes region of Açıkbaş et al. (2017). The reason for the difference in values is that the alfalfa samples were grown by the researchers. Unfortunately, the current results do not agree with the results of alfalfa consumed by the animals during the feeding phase. While the current results were determined higher than our study, the ADF % (31.6) and NDF % (41.2) values were found to be higher. The high structural carbohydrate values of alfalfa samples are attributed to the shedding of most of their leaves during harvest, transport, or stowing. This also might be attributed to the nutritional losses during harvesting, transport, and stowing, depending on dry matter content of roughages and allowed time for drying on field. Yücel et al. (2013) determined the average CP, ADF, NDF % and RFV of vetch grown in Eastern Mediterranean conditions as 20.71, 37.81, 44.49% and 114.2, respectively, while similarly, Ova and Uslu (2021) determined the dry grass of three types of vetch determined in Eastern Mediterranean conditions as 18.75, 34.16, 47.75% and 122.65, respectively. When compared with our current study, all results support that the leaves of the vetch, which contain higher crude protein compared to other parts of plant, are shed until they reach their final use. When the RFV is examined, it was seen that the vetch hay and vetch stalk have a second-class feed value (Table 1 and 3). Considering the reviewed literature, the CP value of the vetch stalk was low in the present study. Since the ADF and NDF values of vetch hay and vetch stalk were not close to each other, the relative feed value was also found similar. For this reason, the RFQ was calculated to determine the period in which roughages should be used in dairy or beef cattle instead of evaluating them only with the RFV. According to the RFQ, alfalfa hay and vetch stalk can be used in heifer, 12 to 18 months beef cow-calf feeding. These outcomes outlined that the importance of handling methods from harvesting roughages to present to animals. This is very important for legumes since their leaves are more vulnerable to physical tach. Our current results showing a serious loss of quality in legumes were clear evident for this. While the average CP, ADF, NDF% and RFV of barley stalk grown in Western Mediterranean conditions were 3.20, 46.93, 74.02 and 67.72%, respectively, Uzun (2010) determined the barley straw grown in Samsun conditions as 5.57, 48.83, 75.86% and 62.80, respectively. According to RFV, barley straw and stalk have been determined that were too bad feed to be used in animal feeding. Similarly, while the average values of wheat fodder were determined as 9.25, 40.70, 67.64% and 78.69, respectively, according to RFV evaluation of wheat fodder was a fourth quality feed. However, the values of Canbolat (2012) for the wheat fodder obtained in Bursa-Türkiye conditions were determined as 8.60, 27.60, 49.90% and 125.70, respectively, and according to RFV is a first quality feed (Table 1 and 3). According to the current results, wheat fodder was seriously compromised from its quality until it was brought to livestock farms and offered for animal consumption. In the present study, when the average CP, ADF, NDF % and RFV of wheat stalk were determined as 2.72, 56.08, 88.25% and 48.88, respectively, while Abdi and Kılıç (2018) mean values of wheat straw obtained in Samsun-Türkiye conditions were determined 2.93, 47.53, 78.89% and 61.2, respectively. The results show that wheat stalk was a poor-quality roughage in terms of animal feeding, just like barley stalk. The average values of oat stalk were determined as 8.93, 39.65, 67.35% and 80.84, respectively, while Canbolat (2012) determined the average values of oat straw grown in Bursa-Türkiye conditions as 7.70, 24.90, 46.60% and 138.70, respectively. In the present study, although oat stalk was a fourth quality feed, Canbolat (2012) determined that it was a first quality feed. In addition, average CP, ADF, NDF% and RFV of grass hay were determined as 12.80, 40.74, 57.97% and 99.50, respectively, while Gürsoy and Macit (2017) mean values of grass hay grown in Erzurum-Türkiye conditions were determined 11.07, 29.97, 59.66% and 102.19, respectively. Grass hay grown in the Western Mediterranean conditions was determined as a fourth quality feed since there was loss due to the physical structure of the grass hay, while the grass hay grown in Erzurum-Türkiye conditions where the high altitude and climate structure was hard had been determined as a fourth quality roughage source.

Barley-oat stalk, barley-wheat stalk, barley-vetch stalk, and vetch-oat stalk mixed have been usually obtained as roughage in the Western Mediterranean Region. While the average CP, ADF, NDF, TDN% and RFV of mixed-grown vetch-oat stalk was 13.69, 35.45, 57.27, 62.92% and 100.49, respectively. Lithourgidis et al. (2006) determined these respective values of vetch-oat straw as 11.00, 35.14, 40.17,

49.49% and 142.08. The average CP, ADF, NDF% and RFV of the barley-oat stalk mixture were determined as 8.68, 36.54, 61.96% and 93.21, respectively, while Seydoşoğlu et al. (2020) determined these parameters in 20% oats and 80% barley straw mixture as 9.43, 40.60, 53.20% and 100.25, respectively. The average CP, ADF, NDF% and RFV of the barley-vetch stalk mixture were determined as 10.62, 37.58, 61.46% and 92.58, respectively, while Uzun and İdikut (2012) determined these parameters for barley-vetch straw mixtures as 14.19, 41.45, 61.64 and 85.57, respectively. Their results also differed according to the mixing ratio of roughages. As can be seen in Table 3, the energy values of roughages were not significantly different among each other, agreeing with those of previous studies in the literature.

CONCLUSIONS

Feed crops used in all animal feeding in the Western Mediterranean-Türkiye are generally obtained by special planting and harvesting methods, and the nutrient contents of these plants are given in the literature. However, the nutrient analysis of collected samples of roughages from animal farms provided us in-depth information about the roughages' history from how to having been treated with them till feeding procedure after harvesting such as, drying, transporting, stewing in the Western Mediterranean Region of Türkiye. In the light of this information, the quality of roughages in the farms for feeding animals decreases until the feed boxes. In addition, the qualified roughages required for the animals to show their real performance provide an increase in productivity for the animals.

As a result, new harvesting and handling techniques need to be developed for roughages. In addition, although the region is suitable for growing roughages of good quality, the desired yield cannot be obtained because the farmers continue to traditional production models. For this reason, it was concluded that new harvesting methods and transportation techniques for roughages should be developed, and education extension projects should be prepared to raise the awareness of the breeders. As an alternative way of preventing nutritional losses, roughages in the field should be packaged as haylage. In addition, the results have supported the database of some roughages and eliminated the deficiencies in the literature.

CONFLICT OF INTEREST

There are no conflicts of interest to declare.

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