Journal of Tekirdag Agricultural Faculty
Tekirdağ Ziraat Fakültesi Dergisi

Ocak/January 2025, 22(1)
Başvuru/Received: 14/06/24
Kabul/Accepted: 16/09/24
DOI: 10.33462/jotaf.1501109

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Evaluating the Nutritive Value and Quality of Fodder Pea (*Pisum arvense* L.) Silage Added with Varying Rates of Barley (*Hordeum vulgare* L.) and Wheat (*Triticum aestivum* L. Em Thell) Cracks

Farklı Oranlarda Arpa (*Hordeum vulgare* L.) ve Buğday (*Triticum aestivum* L. Em Thell) Kırığı Eklenen Yem Bezelyesi (*Pisum arvense* L.) Silajının Besleme Değeri ve Kalitesinin Değerlendirilmesi

Ertan ATEŞ[1*], Hazım Serkan TENİKECİER[2]

Abstract

Silage represents the most effective solution for addressing the deficit in quality, abundance and cost-effectiveness of roughage. The main purpose of silage production is to store fresh herbage material with high nutritional value with minimum nutrient loss. For fodder and silage production, fodder pea is grown in mixtures with cereals in different ratios, but also for the silage from the pure fodder pea using additives. Molasses and crashed cereal grains or cereal can be added to silage material in order to increase its carbohydrate content. The research was conducted to determine nutritive value and silage quality of barley and wheat cracks added at different ratios to fodder pea silage in complete randomized split-plot design with four replications. 100 g withered fodder pea sample without additives and 100 g withered fodder pea sample with 3 g, 6 g, 9 g and 12 g cracked barley were vacuumed in to the 20x26 cm plastic bags and were stored in a dark environment for a period of 45 days to facilitate fermentation at ambient temperatures ranging from 15 to 28°C. Crude protein (%), crude ash (%), dry matter (%), digestible dry matter (DDM, %), dry matter intake (DMI, %), ADF (%), NDF (%), P (%), K (%), Ca (%), Mg (%), total digestible nutrients (TDN), Nel, NEm, Neg, pH, Fleig Score and RFV of pure fodder pea and cracked barley and wheat added silages were determined. According to results, fodder peas, which have a high protein and low carbohydrate content, be ensiled by the addition of high-carbohydrate wheat and barley cracks in order to obtain a quality silage. For this purpose, it is suggested to add at least 6% wheat cracks or 9% barley cracks to fodder pea silage.

Keywords: Cereal cracks, Fleig score, Fodder pea, Mineral content, Silage

[1]***Sorumlu Yazar/Corresponding Author:** Ertan Ateş, Tekirdağ Namık Kemal University, Faculty of Agriculture, Field Crops Department, Tekirdağ, Türkiye. E-mail: ertan_ates@hotmail.com OrcID: 0000-0002-3048-497X

[2]Hazım Serkan Tenikecier, Tekirdağ Namık Kemal University, Faculty of Agriculture, Field Crops Department, Tekirdağ, Türkiye. E-mail: hstenikecier@nku.edu.tr OrcID: 0000-0002-1866-410X

Atıf: Ateş, E., Tenikecier, H. S. (2025). Farklı oranlarda arpa (*Hordeum vulgare* L.) ve buğday (*Triticum aestivum* L. Em Thell) kırığı eklenen yem bezelyesi (*Pisum Arvense* L.) silajının besleme değeri ve kalitesinin değerlendirilmesi. *Tekirdağ Ziraat Fakültesi Dergisi,* 22(1): 187-194.

Citation: Ateş, E., Tenikecier, H. S. (2025). Evaluating the nutritive value and quality of fodder pea (*Pisum Arvense* L.) silage added with varying rates of barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L. Em Thell) cracks. *Journal of Tekirdag Agricultural Faculty,* 22(1): 187-194.

Öz

Silaj, kaba yemlerin yetersizliğini, kalitesizliğini ve kaba yem üretiminin maliyet etkinliğinin karşılanması açısından en etkili çözümü temsil eder. Silaj üretiminin ana amacı, yüksek besin değerine sahip taze kaba yem materyalinin minimum besin kaybıyla depolanmasıdır. Yem bezelyesi kuru-yeşil ot ve silaj üretimi için farklı oranlarda tahıllarla karışımlar halinde yetiştiriciliği yapılırken, ayrıca katkı maddeleri kullanılarak saf yem bezelyesi silajı da elde edilmektedir. Melas ve tahıl veya kırılmış tahıl taneleri, silaj materyaline karbonhidrat içeriğini artırmak amacıyla eklenebilir. Bu araştırma, yem bezelyesi silajına farklı oranlarda eklenen arpa ve buğday kırıklarının, silajın besin değerini ve kalitesine etkisini belirlemek için tesadüf parselleri deneme desenine göre dört tekrarlamalı olarak yürütülmüştür. 100 g katkısız soldurulmuş yem bezelyesi ile 100 g katkısız soldurulmuş yem bezelyesine 3 g, 6 g, 9 g ve 12 g arpa ve buğday eklenmiş yem bezelyesi örnekleri 20x26 cm plastik torbalara vakumlanmış ve karanlık bir ortamda 15 ila 28°C arasında değişen ortam sıcaklıklarında 45 gün boyunca fermantasyonun kolaylaştırılması için depolanmıştır. Saf yem bezelyesi ile arpa ve buğday kırıkları eklenmiş silajların ham protein (%), ham kül (%), kuru madde (%), sindirilebilir kuru madde (DDM, %), kuru madde tüketimi (DMI, %), ADF (%), NDF (%), P (%), K (%), Ca (%), Mg (%), toplam sindirilebilir besin elementi içeriği (TDN), Nel, NEm, Neg, pH, Fleig Skoru ve nispi yem değeri (RFV) belirlenmiştir. Sonuçlara göre, yüksek protein ve düşük karbonhidrat içeriğine sahip olan yem bezelyesinden kaliteli bir silaj elde etmek için yüksek karbonhidratlı buğday ve arpa kırıklarının eklenmesiyle silolanabileceği belirlenmiştir. Bu amaçla, yem bezelyesi silajına en az %6 buğday kırığı veya %9 arpa kırığı eklenmesi önerilmektedir.

Anahtar Kelimeler: Tahıl kırığı, Fleig skoru, Yem bezelyesi, Mineral içeriği, Silaj

1. Introduction

It is documented that in ancient Egypt, water-rich feeds were stored in containers with no contact with air. In Europe, the silage production has started to develop in the 18. century. The introduction of silage in Turkey has a history of approximately 80-90 years, with the first silage production taking place at Atatürk Forest Farm. In the 1970s, the technology began to be recognised by animal breeders, with promotional projects being carried out and silage machines being provided to some enterprises. These endeavours have made a considerable contribution to the enhancement of feed management and animal nutrition. In recent years, with the growing importance and incentives given to animal husbandry, there has been an increasing need for high-quality, abundant, and cheap roughages for the feeding of cultivated and hybrid animals, the number of which has reached significant dimensions, albeit insufficient. Consequently, silage represent the most effective solution for addressing the deficit in quality, abundance and cost-effectiveness of roughage.

The main purpose of silage production is to store fresh herbage material with high nutritional value with minimum nutrient loss (Burgu and Mut, 2023). It is possible to produce silage from a variety of plants. The most prevalent silage crops currently in use are maize, sorghum, Sudan grass, sorghum-Sudan grass hybrid varieties, other grasses, legumes and legume-grasses mixtures. Furthermore, vegetable residues, canned sugar, waste products from fruit juice production, as well as some tree leaves and fruits, are also utilised in the process (Yıldırım, 2015; Özdemir and Okumuş, 2021). Nevertheless, it's essential that the plant intended for ensiling possesses suitable dry matter content and readily soluble carbohydrates for effective ensiling. The low dry matter content of forage legumes, such as fodder peas, the low water-soluble carbohydrates and high buffer capacity of legumes cause them to be difficult to ensilage (Yücel et al., 2013). In their respective studies, Jones et al. (1990) and Jacobs et al. (1995) demonstrated that the incorporation of cereal grains or beet pulp into green fodders with low dry matter content enhances the fermentation properties of silage.

For fodder and silage production, fodder pea is grown in mixtures with cereals in different ratios, but also for the silage from the pure fodder pea using additives. Due to the ready availability of molasses and crashed cereal grains or cereal cracks in the market, these are added to silage material in order to increase its carbohydrate content (Gülümser et al., 2019). Besides, many livestock breeders also ask whether wheat (*Triticum* sp.) or barley (*Hordeum vulgare* L.) grains can be added to fodder pea silage and in what quantity. In order to answer this question, this study was carried out to determine the effect of barley and wheat cracks on the quality of pure fodder pea silage.

2. Materials and Methods

The fodder pea (variety 'Töre') for the research were sown on 15 November 2022, with a row spacing of 25 cm and a seeding rate of 120 kg per hectare (Ates et al., 2020) on a 5-hectare farmer's field located in Gazioğlu, Süleymanpaşa-Tekirdağ, Türkiye. A basal fertilizer containing nitrogen (N) and phosphorus (P) at a rate of 50 kg per hectare was incorporated into the soil during land preparation. Fresh samples were taken at the full-bloom stage at a height of 3 cm above the ground (Tenikecier and Ates, 2021). The samples were left to wither for 2 hours and then approximately 1.5-2 cm chopped by mechanically (Er and Mut, 2023). Grains of barley variety 'Kristal' and wheat variety 'LG-59 'were subjected to a mechanical cracking process. 100 g withered fodder pea sample without additives and 100 g withered fodder pea samples with 3 g, 6 g, 9 g and 12 g cracked barley and wheat (separately for both species) were vacuumed (İleri et al., 2022; Tenikecier and Ateş, 2024) in to the 20x26 cm plastic bags and were stored in a dark environment for a period of 45 days to facilitate fermentation at ambient temperatures ranging from 15 to 28°C (Jia et al., 2021). After 45 days, the pH of the silages was measured using a pH meter. The research was conducted in complete randomized split-plot design with four replications.

It is well-documented that oven drying feed samples at temperatures exceeding 60°C can result in heat-damaged protein and increased values of fiber and lignin. Furthermore, oven drying feedstuffs containing proanthocyanidins, even at temperatures below 60°C, has been shown to increase neutral detergent fiber (NDF), fiber-bound nitrogen, and lignin content (Reed and Van Soest, 1984). To determine the dry matter content, the matured silage samples were dried to a constant weight in an air oven at 60°C for 48 hours, followed by a subsequent day of storage at ambient temperature (Tenikecier and Ateş, 2024). The samples were then ground to small pieces (≤1 mm) and utilized for analysis. The N content was analyzed following the procedures outlined by the Association of Official Analytical Chemists (AOAC, 2019). The crude protein content (%) was calculated by multiplying the nitrogen content by a factor of 6.25. The samples were wet-digested with a nitric-perchloric acid mixture, and P (%) content was determined spectrophotometrically. The potassium (K, %), calcium (Ca, %), and magnesium (Mg, %) contents were quantified using an inductively coupled plasma-optical emission spectrometer (ICP-OES) (Isaac and Johnson JR, 1998). Crude ash (%), acid detergent fiber (ADF, %), and NDF (%) contents were determined using Weende and Van Soest methodologies (AOAC, 2019; Van Soest et al., 1991). All analyses were conducted in duplicate. The digestible dry matter (%), dry matter intake (%), relative feed value (%), total digestible nutrients (TDN), net energy for lactation (NEl), net energy for maintenance (NEm), and net energy for gain (NEg) were calculated using established equations for forage evaluation (Schroeder, 1994). Fleig score was calculated using the formula suggested by Kılıç (1986).

Statistical analysis of all data was performed using analysis of variance (ANOVA) with TARIST software (Açıkgöz et al., 1994), and treatment means were compared using the least significant difference (LSD) test, implemented with MSTAT-C software.

3. Results and Discussion

The results are given in *Tables 1* to *3*. There were no statistically significant difference between means of DMI, NEl, Neg (P>0.05).

Table 1. The crude protein, crude ash, dry matter, digestible dry matter, dry matter intake, acid detergent fiber and neutral detergent fiber of ensiled fodder pea, cracked wheat and barley grains added fodder pea silage

	Crude Protein (%)	Crude Ash (%)	Dry Matter (%)	DDM (%)	DMI (%)	ADF (%)	NDF (%)
Fodder Pea	19.78a	3.52f	38.30bc	67.83c	3.15	27.05f	38.05bc
Fodder Pea+3% cracked barley	17.17g	3.90e	38.51abc	67.66f	3.14	27.26d	38.26abc
Fodder Pea+3% cracked wheat	17.52f	4.08d	37.90c	67.98a	3.19	26.85h	37.65c
Fodder Pea+6% cracked barley	17.54f	4.11d	38.58abc	67.61f	3.20	27.33c	38.33abc
Fodder Pea+6% cracked wheat	17.71de	4.21c	38.98ab	67.91b	3.10	26.94g	38.73ab
Fodder Pea+9% cracked barley	17.64ef	4.22bc	38.86ab	67.53h	3.11	27.43b	38.61ab
Fodder Pea+9% cracked wheat	17.88c	4.31b	39.05ab	67.83c	3.09	27.05f	38.80ab
Fodder Pea+12% cracked barley	17.80cd	4.64a	38.99ab	67.44ı	3.10	27.55a	38.74ab
Fodder Pea+12% cracked wheat	18.24b	4.56a	39.31a	67.78d	3.07	27.12e	39.06a
Mean	*17.92*	*4.17*	*38.72*	*67.73*	*3.13*	*27.18*	*38.47*
LSD	0.160**	0.094**	0.932**	0.041**	ns	0.051**	0.932**

The highest crude protein (19.78%) and lowest crude ash (3.52%) ratios were found in pure fodder pea silage. While the highest DDM (67.98%) was determined in fodder pea+3% cracked wheat silage, the lowest dry matter (37.90%), ADF (26.85%) and NDF (37.65%) contents were recorded in the same treatment (P<0.01). The DMI values varied between 3.07 to 3.20% (*Table 1*). The addition of cereal cracks to silage has resulted in decreases in the crude protein content of the silage. This situation arises from the lower crude protein content of the additives compared to pure fodder pea. Indeed, in a study, the crude protein content in barley grains was determined to be 5.5% (Acar and Bostan, 2016). These researchers reported that the inclusion of barley cracks, molasses, and whey additives in various ratios resulted in alfalfa (*Medicago sativa* L.) silages with ADF and NDF contents ranging from 30.85% to 32.59% and from 39.69% to 41.20%, respectively. Turgut et al. (2005) reported that the significant relations between silage and silage material in terms of NDF and ADF contents. Yavuz et al. (2009) recommended that the ADF content of feeds used in the nutrition of high-yielding dairy cattle should be 30% or less, while the NDF content should be 40% or less. Heuze et al. (2017) reported that the crude protein and digestibility ratios decrease when the dry matter ratio increase. Gülümser et al. (2019) found that the silages with ADF and NDF contents ranging from 24.60% to 42.75% and from 35.97% to 55.07%, respectively. İleri et al. (2022) also indicated that silage fermentation is delayed and quality is reduced under low carbohydrate conditions. The results of our analysis of NDF and ADF contents were found to be consistent with those of previous studies (Geren, 2001; Heuze et al., 2017).

While the highest P ratio (0.38%) was found in fodder pea+3% cracked wheat silage, the lowest K (1.65%) in and Ca (0.98%) contents were determined in fodder pea+12% cracked wheat and fodder pea+12% cracked barley silages respectivcely (*Table 2*). The highest Mg content (0.39%) was identified in fodder pea silage with 3%

cracked barley, while the lowest TDN value (64.67) was calculated in fodder pea silage with 12% cracked barley. Tekeli and Ates (2005) asserted that the K content in roughage should be between 0.6% and 0.8%, the P content between 0.18% and 0.39%, the Ca content between 0.18% and 0.44%, and the Mg content between 0.04% and 0.10% in order to meet the nutritional requirements of dairy and beef cattle. The skeletal system holds a significant portion of Mg, comprising approximately 68-73% of the total Mg content in an animal's body. Additionally, the presence of P in the rumen is vital, as higher levels of P promote Mg absorption. In instances where animals graze on phosphorus-deficient pastures, the rumen may have low concentrations of P, further hindering Mg absorption. Moreover, the Ca levels in the blood also influence these processes (Ates, 2017). It is observed that the mineral contents in silages are at levels sufficient to meet the needs of animals.

Table 2. The mineral contents of ensiled fodder pea, cracked wheat and barley grains added fodder pea silage

	P (%)	K (%)	Ca (%)	Mg (%)	TDN
Fodder Pea	0.31f	1.99b	1.19b	0.36c	65.24b
Fodder Pea+3% cracked barley	0.36c	2.02a	1.22a	0.39a	65.00d
Fodder Pea+3% cracked wheat	0.38a	1.96c	1.21a	0.38b	65.47a
Fodder Pea+6% cracked barley	0.33d	1.96c	1.17c	0.38b	64.93d
Fodder Pea+6% cracked wheat	0.37b	1.86d	1.11d	0.36c	65.40a
Fodder Pea+9% cracked barley	0.32e	1.87d	1.09e	0.35d	64.80e
Fodder Pea+9% cracked wheat	0.36c	1.75e	1.11d	0.34e	65.24b
Fodder Pea+12% cracked barley	0.30g	1.75e	0.98g	0.31f	64.67f
Fodder Pea+12% cracked wheat	0.33d	1.65f	1.06f	0.31f	65.17c
Mean	*0,34*	*1.87*	*1.13*	*0.35*	*65.10*
LSD	0.005**	0.024**	0.014**	0.007**	0.071**

Table 3. The Fleig score, NEI, Nem, NEg, pH and RFV of ensiled fodder pea, cracked wheat and barley grains added fodder pea silage

	NEl	NEm	NEg	pH	Fleig Score	RFV
Fodder Pea	0.67	0.73	0.40	4.50a	101.47c	165.84ab
Fodder Pea+3% cracked barley	0.67	0.72	0.40	4.40ab	106.15bc	164.51abc
Fodder Pea+3% cracked wheat	0.68	0.73	0.40	4.37abc	106.13bc	168.15a
Fodder Pea+6% cracked barley	0.67	0.72	0.40	4.41ab	105.76bc	164.09abc
Fodder Pea+6% cracked wheat	0.67	0.73	0.40	4.19de	115.35a	163.13bc
Fodder Pea+9% cracked barley	0.67	0.72	0.40	4.25cde	112.86a	162.68bc
Fodder Pea+9% cracked wheat	0.67	0.73	0.40	4.19de	115.24a	162.60bc
Fodder Pea+12% cracked barley	0.67	0.72	0.39	4.16e	116.58a	161.94bc
Fodder Pea+12% cracked wheat	0.67	0.73	0.40	4.31bcd	111.35ab	161.43c
Mean	*0.67*	*0,73*	*0.40*	*4.31*	*110.10*	*163.82*
LSD	ns	ns	ns	0.133**	5.620**	4.278**

The Nel, NEg and NEm values varied between 0.67-0.68, 0.39-0.40 and 0.72-0.73, respectively (P>0.05). The applications of barley and wheat cracks were lowered the pH of the silage (*Table 3*). The lowest pH were measured in fodder pea+12% cracked barley (4.16), fodder pea+6% cracked wheat (4.19), fodder pea+9% cracked wheat (4.19) and fodder pea+9% cracked barley (4.25) silages (P<0.01). One of the most important factors in determining the quality of silage is a low pH. The low pH is of significant importance in terms of proteolysis, which is the process that leads to the deterioration of silage. Consequently, in order for proteolysis to cease completely, the pH of the silage must be reduced to below 4 (Virtanen, 1993; Gülümser et al., 2019). In a good silage, there is a close relationship between pH value and Flieg score of silage (Kılıç, 2010; Er and Mut, 2023). The lowest Fleig scores were calculated in fodder pea (101.47), fodder pea+6% cracked barley (105.76), fodder pea+3% cracked wheat (106.13) and fodder pea+3% cracked barley (106.15) silages (P<0.01). Karaevli and Baytekin (2018) added barley cracks and inoculant to silages made from wheat, barley, triticale, oats, and rapeseed herbages in varying proportions. The researchers reported that the positive improvements in silage characteristics as the amount of barley cracks and inoculant increased. Gülümser et al. (2019) demonstrated that the incorporation of molasses or barley cracks at varying proportions into cowpea (*Vigna unguiculata* L.) and soybean (*Glycine max* L.) crops enhanced silage quality. Among the tested silages, those containing soybean and 5% barley cracks exhibited superior performance. The relative feed value index is a measure of the quality of a given fodder. As the RFV of a given fodder decreases, its quality also decreases (Önal Aşçı and Acar, 2018). The relative feed values were varied between 161.43-168.15 (*Table 3*). The relative feed values were opposite to the reports of Canbolat et al. (2019), who reported that the values increased when molasses was added to the fodder pea silage. Tenikecier and Ateş (2024) suggested adding 12% cracked oat grains to fodder peas during ensiling to achieve high-quality silage based on Fleig scores.

4. Conclusions

In conclusion, it is recommended that fodder peas, which have a high protein and low carbohydrate content, be ensiled by the addition of high-carbohydrate wheat and barley cracks in order to obtain a quality silage. For this purpose, it is suggested to add at least 6% wheat cracks or 9% barley cracks to fodder pea silage.

Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Ateş, E., Tenikecier, H. S.; Design: Ateş, E., Tenikecier, H. S.; Data Collection or Processing: Ateş, E., Tenikecier, H. S.; Statistical Analyses: Ateş, E., Tenikecier, H. S.; Literature Search: Ateş, E., Tenikecier, H. S.; Writing, Review and Editing: Ateş, E., Tenikecier, H. S.

References

Acar, Z. and Bostan, M. (2016). The effects of some natural additives on quality of alfalfa silage. *Anadolu Journal of Agricultural Sciences*, 31(3): 433-440. https://doi.org/10.7161/omuanajas.269998

Açıkgöz, N., Akbaş, M. E., Moghaddam, A. and Özcan, K. (1994). Database-Based Turkish Statistics Program for PCs: TARIST. *Turkey 1st Field Crops Congress*, 25-29, April, p: 264–267, İzmir, Türkiye.

AOAC (2019). Official Methods of Analysis of AOAC International. 21st Ed, Association of Official Analytical Chemists, USA.

Ates, E. (2017). Slope aspect has effects on vegetation and forage traits of anthropogenic pasture under two grazing treatments. *Revista de la Facultad de Agronomía de la Universidad del Zulia*, 34: 236-252.

Ates, E., Tenikecier, H. S. and Ozkan, U. (2020). The dry matter yield, -tocopherol, -carotene and some mineral contents in fodder pea (*Pisum arvense* L.) varieties at different growth stages. *Comptes Rendus de l'Academie Bulgare des Sciences*, 73(4): 579-586. https://doi.org/10.7546/CRABS.2020.04.18

Burgu L. and Mut, H. (2023). Silage yield and some quality traits of silage maize varieties growing as second crop. *Journal of Tekirdag Agricultural Faculty*, 20 (1): 12-24. https://doi.org/10.33642/jotaf.1039381

Canbolat, Ö., Akbay, K. C. and Kamalak, A. (2019). Possibilities of use of molasses as carbohydrate source in pea silages. *Journal of Agriculture and Nature*, 22(1): 122-130. https://doi.org/10.18016/ksutarimdoga.vi.455713

Er, E. and Mut, H. (2023). Determination of silage quality of mixtures of berseem clover (*Trifolium resupinatum* L.) and annual ryegrass (*Lolium multiflorum* Lam.) under Bilecik conditions. *ISPEC Journal of Agricultural Sciences*, 7(4): 730-738. https://doi.org/10.5281/zenodo.10207729

Geren, H. (2001). Effect of sowing dates on silage characteristics of different maize cultivars grown as second crop under Bornova conditions. *Journal of Agriculture Faculty of Ege University*, 38: 47-54.

Gülümser, E., Mut, H., Başaran, U. and Çopur Doğrusöz, M. (2019). Effects of molasses or crushed barley addition on the quality of cowpea and soybean silages. *BSEU Journal of Science*, 6: 161-167. https://doi.org/10.35193/bseufbd.589388

Heuze, V., Tran, G., Edouard, N. and Lebas, F. (2017). Maize Silage. Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. https://feedipedia.org/node/13883 (Accessed Date: 01.06. 2024).

İleri, O., Kara, E., Erkovan, Ş., Sürmen, M., Erkovan, H. İ. and Koç, A. (2022). Silage quality of corn grown at different weed densities. *Turkish Journal of Range and Forage Science*, 3(2): 36-40. https://doi.org/10.51801/turkjrfs.1092563

Isaac, R. A. and Johson JR, W. C. (1998). Handbook of Reference Methods for Plant Analysis. (Ed: Kalra, Y.P.). Elemental Determination by Inductively Coupled Plasma Atomic Emission Spectrometry. CRC Press, Washington DC, USA, 165-170.

Jacobs, J. L., Morris, R. J. and Zorrilla-Rios, J. (1995). Effect of ensiling whole barley grain with pasture on silage quality and effluent production, and the performance of growing cattle. *Australian Journal of Experimental Agriculture*, 35: 731-738.

Jia, T., Wang, B., Yu, Z. and Wu, Z. (2021). The effects of stage of maturity and lactic acid bacteria inoculants on the ensiling characteristics, aerobic stability and in vitro digestibility of whole-crop oat silages. *Grassland Science*, 67: 55–62. https://doi.org/10.1111/grs.12285

Jones, D. I. H., Jones, R. and Moseley. G. (1990). Effect of incorporating rolled barley in autumn cut ryegrass silage on effluent production, silage fermentation and cattle performance. *Journal of Agricultural Science*, 115: 399-408.

Karaevli, M. E. and Baytekin, H. (2018). Investigation of the Possibilities of Using Some Winter Annual Field Crops in Silage Production in Trakya Region. *COMU Journal of Agricultural Faculty*, 6: 249-254. https://doi.org/10.33202/comuagri.504361

Kılıç, A., 1986. Silo Feed (Production, Learning and Application Recommendations) [Silo Yemi (Üretim, Öğrenim ve Uygulama Önerileri)]. Bilgehan Basımevi, İzmir, Türkiye. (In Turkish)

Kılıç, A., 2010. Silo Feed [Silo Yemi]. Hasad Yayıncılık, İstanbul, Türkiye. (In Turkish)

Önal Aşçı, Ö. and Acar, Z. (2018). Quality in Forages [Kaba Yemlerde Kalite]. TMMOB Chamber of Agricultural Engineers, Ankara, Türkiye. (In Turkish)

Özdemir, M. and Okumuş, O. (2021). Some silage studies made in Turkey in the last five years. *Erciyes Tarım ve Hayvan Bilimleri Dergisi*, 4(2): 30-39.

Reed, J. D. and Van Soest, P. J. (1984). Estimating the nutritive value of crop residue and agro-industrial by-products by chemical methods. *Proceedings of the FAO/ILCA Expert Consultation*, 5–9 March, Addis Ababa, Ethiopia.

Schroeder, J. W. (1994). Interpreting Forage Analysis. Extension Dairy Specialist (NDSU), AS-1080, North Dakota State University.

Tekeli, A. S. and Ates, E. (2005). Yield potential and mineral composition of white clover (*Trifolium repens* L.)-tall fescue (*Festuca arundinacea* Schreb.) mixtures. *Journal of Central European Agriculture*, 6: 27-34.

Tenikecier, H. S. and Ates, E. (2021). Yield, some cell wall components and mineral content of fodder pea (*Pisum arvense* L.) forage as influenced by cultivar, growth stages and phosphorus application. *Journal of Elementology*, 26(2): 319-332. https://doi.org/10.5601/jelem.2021.26.1.2118

Tenikecier, H. S. and Ateş, E. (2024). Effect of adding different ratios of oat (*Avena sativa* L.) cracks on the silage quality of fodder pea (*Pisum arvense* L.). *ISPEC Journal of Agricultural Sciences*, 8: 638-646.

Turgut, I., Duman, A., Bilgili, U. and Acikgoz, E. (2005). Alternate row spacing and plant density effects on forage and dry matter yield of corn hybrids (*Zea mays* L.). *Journal of Agronomy and Crop Science*, 191: 146-151.

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fibre, neutral detergent fibre, and nonstarch polysaccharides in relation to animal nutrition. *Journal of Dairy Science*, 74: 3583–3597.

Virtanen, A. I. (1993). The A. I. V. method of preserving fresh fodder. *Empire Journal of Experimental Agriculture*, 1: 143-155.

Yavuz, M., İptaş, S., Ayhan, V. and Karadağ, Y. (2009). Quality of Forages and Nutritional Disorders Caused by Forages [Yem bitkilerinde Kalite ve Yem bitkilerinden Kaynaklanan Beslenme Bozuklukları]. Republic of Türkiye, Ministry of Agriculture and Forestry, Ankara, Türkiye, 163-186. (In Turkish)

Yıldırım, B. (2015). Silage studies in Turkey: 2005-2014. *Iğdır Universtiy Journal of Institiuon of Science & Technology*, 5(2): 79-88.

Yücel, C., Avcı, M., Kılıçalp, N. and Akkaya, M. R. (2013). The silage characteristics of legume, grasses and mixtures of siled with *Lactobacillus buchneri*. *Journal of Tekirdag Agricultural Faculty*, 10(3): 11-18.