Turkish Journal of Range and Forage Science

Volume: 6 **Number**: 1 **Year**: 2025 E-**ISSN**:2718-0492

Published by Society of Range and Forage Science

Society of Range and Forage Science

TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

Volume **6** Issue **1** **2025**

TURKISH JOURNAL OF RANGE AND FORAGE SCIENCE

(International Refereed Journal)

Published by the Society of Range and Forage Science, Aydin, TÜRKİYE

Aims and Scope

Turkish Journal of Range and Forage Science is the official publication of Society of Rangeland and Forage Science. The Journal is dedicated to publishing quality original material that advances rangeland management and forage crops production.

Turkish Journal of Range and Forage Science is a peer-reviewed, international, electronic journal covering all aspects of range, forage crops and turfgrass management, including the ecophysiology and biogeochemistry of rangelands and pastures, terrestrial plant–herbivore interactions, rangeland assessment and monitoring, effects of climate change on rangelands and forage crops, rangeland rehabilitation, rangeland improvement strategies, conservation and biodiversity goals. The journal serves the professions related to the management of crops, forages and grazinglands, and turfgrass by publishing research, briefs, reviews, perspectives, and diagnostic and management guides that are beneficial to researchers, practitioners, educators, and industry representatives.

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Turkish Journal of Range and Forage Science is published twice a year (June and December) as online.

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The publication process of the Turkish Journal of Range and Forage Science takes place within the framework of ethical principles. The procedures in the process support the quality of the studies. For this reason, it is of great importance that all stakeholders involved in the process comply with ethical standards.

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Initial Manuscript Evaluation

All manuscripts submitted for publication in Journal are firstly evaluated by the Technical Editor. Manuscripts which fall outside the aims and scope of the journal or is not enough for requirements of a scientific study are rejected or may be wanted some revisions at this initial point. Manuscripts are never accepted by editor without a reviewer report, at this early stage.

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When a revision is required by the reviewer or reviewers, the author(s) are to consider the criticism and suggestions offered by the reviewers, and they should be sent back the revised version of manuscript in twenty days. If revised manuscript is not sent in twenty days, the manuscript is removed from reviewer evaluation process. Reviewers may request more than one revision of a manuscript. Manuscripts which are not accepted for publication are not re-sent to their authors.

Final Evaluation

After favorable opinions of reviewers, Editorial Board is made the final evaluation. The articles accepted for publication by Editorial Board are placed in an issue sequence.

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The peer review process that has long time is an important problem. Naturally, the author(s) wish to take an answer about their submissions. Turkish Journal of Range and Forage Science aims to complete the all peer review process within 8 weeks after submission (one week for initial evaluation, 6 weeks for reviewer evaluation and one week for final evaluation).

The author(s) that submit an article to the Turkish Journal of Range and Forage Science consider accepting of these peer review conditions and procedures.

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Research

Turkish Journal of Range and Forage Science
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Some Soil Chemical Properties at Different Depths in the Inner and Outer of the Plant Canopy of Russian Thistle

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A R T I C L E I N F O

Received *15/11/2024*
Accepted *15/01/2025*

Keywords:
pH,
soil,
EC,
lime,
organic matter,
mineral matter

A B S T R A C T

This study was carried out to determine the acidity (pH), electrical conductivity (EC), lime, organic matter (OM), nitrogen (N), calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and phosphorus (P) contents at different soil depths in the inner and outer of the plant canopy of Russian thistle (*Salsola ruthenica* Iljin) growing under the ecological conditions of Iğdır province. The study was conducted in 2023 according to the split-plot experimental design with three replications. According to the research results, it was observed that there were significant differences in pH, lime, calcium, potassium and magnesium contents in the soils taken from inner and outer the plant canopy Compared to the soils taken outer the canopy, the pH value and calcium content of the soils taken inner the canopy were lower, while the lime, potassium and magnesium contents were higher. Significant changes were observed in the EC, nitrogen, calcium, potassium, magnesium and sodium contents of the soils taken from different depths. The highest EC value and calcium content were determined at 0-20 and 20-40 cm soil depth. Nitrogen content was determined at 0-20 and 40-60 cm soil depth, potassium and sodium contents were determined at 40-60 cm soil depth, and magnesium content was determined at 20-40 cm soil depth.

1. Introduction

The factors affecting soil formation are diverse and complex in their interactions and have caused the formation of areas with different levels of soil properties on the earth's surface. In addition, the biological, chemical and physical properties of the soil may change due to biological and geological or anthropogenic activities (Zúñiga et al., 2019). The chemical differences that these changes cause in the soil depth are very important for the development of plants. Soil depth provides more mechanical support to the plant as well as more water and nutrients to the plant (Rajakaruna & Boyd, 2008). Therefore, the changes that occur along the soil profile in the inner canopy of plants growing in semiarid and arid areas are of great importance for the formation of productive areas. Many chemical reactions that affect plant nutrient availability have also been reported to affect soil pH (Schoenholtz et al., 2000). The presence of sufficient amounts of suitable plant nutrients in the soil, the organic matter, texture, structure, pH and EC value of the soil are factors that significantly affect the fertility of the soil. At the same time, these factors are indicators of obtaining healthy food from the soil and the health of humans and animals (Papendick & Parr, 1992; Doran & Parkin, 1994).

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Considering all these, practices that will contribute to soil fertility are of great importance. In areas with arid and desert ecosystems, vegetation has important contributions to soil properties. The vegetation cover and overgrazing of plants in these areas have three important effects on both the distribution of vegetation and soil properties. The first of these is the change in vegetation cover following overgrazing, the second is the contributions to the soil by increasing the number of plants in the area, and the third is the benefits to the soil and ecosystem as a result of the expansion of plant-covered areas (Zheng et al., 2008).

Russian thistle is used fresh as a salad by humans and as feed for sheep and goats. It is also used in various treatments in the field of health; it is effective against bee and insect stings (Moerman, 1998). This plant is common in forests, roadsides, deserts, poorly managed meadows and pastures, and can grow in areas up to 1750 meters in altitude (Dimen, 2016). This plant, which is adapted to regions with dry summers and cold winters, is more common in semi-arid areas (Mosyakin, 1996). It is widespread in Asia, Europe and North Africa, and is also found in North America and Australia (Wagner et al., 1990). If appropriate plant selection and land management are not made in semi-arid and arid climate regions, it leads to sparse vegetation and increased soil and water losses (Temel & Keskin, 2019).

There is very limited research on how Russian thistle affects the soil structure in the areas where it grows. This research was carried out to determine some chemical (pH, EC, lime, organic matter, N, Ca, K, Mg, Na and P) contents at different soil depths in the inner and outer of canopy areas of russian thistle.

2. Materials and Methods

This study was carried out in the wind erosion area located within the borders of Iğdır province, where marginal soil and climate conditions are effective. When we look at land use, 50.5% (6,842 ha) of the erosion area is used as 2nd class pasture and 49.5% (6,700 ha) is used as heathland (Sevim, 1999). In addition, 80.7% (5,524 hectares) of the existing pasture areas face the problem of stoniness (Demir & Keskin, 2016). The district of Aralık has an average altitude of 825 meters and covers a total area of 13.542 hectares (Özdoğan, 1976).

The research was carried out in randomized blocks with three replications according to the factorial experimental design in 2023. Soil samples were taken from 0-20, 20-40 and 40-60 cm soil depths in the inner/outer of canopy of 5 randomly selected russian thistles in each block.

The pH value in these soil samples was measured with a glass electrode pH meter using a 1:2.5 soil-water mixture (Sağlam, 1994). Electrical conductivity (EC dS m-1) in the filtrates obtained from saturation mud was determined with an electrical conductivity device (Rhoades, 1982). The amount of lime ($CaCO_3$) was determined as a percentage with the Scheibler Calcimeter method (Nelson & Sommers, 1982). Organic matter (OM) content was determined with the Smith-Weldon technique (Nelson & Sommers, 1982). Nitrogen (N) content was determined with the micro Kjeldahl method by applying the wet digestion method with a mixture of salicylic acid and salt (Bremner & Mulvaney, 1982). Exchangeable cations (Na, Ca, K and Mg) were obtained by sodium acetate (1 N, pH = 8.2) and then the solutions were extracted with ammonium acetate (1 N, pH = 7.0) and then read using the ICP-OES device (Rhoades, 1982). Phosphorus content was determined using the blue color method of phosphorus soluble in acid fluoride (Sağlam, 1994).

Variance analyses of the data were performed using the JMP 5.1.0 statistical package program according to the factorial experimental design in randomized blocks, and the grouping of significant means was performed according to the LSD test.

3. Results and Discussion

In this study, which was carried out to determine the EC, pH, organic matter, lime, nitrogen, calcium, sodium, magnesium, potassium and phosphorus contents of soils taken at different depths (0-20, 20-40 and 40-60 cm) and inner/outer of plant canopy, the variance analysis results are presented in Table 1. Among the soil samples taken from the inner and outer of the canopy, lime, calcium, potassium and magnesium contents were found to be statistically significant at $p<0.01$, and soil pH was found to be statistically significant at $p<0.05$ (Table 1.). EC, organic matter, nitrogen, sodium and phosphorus contents of the soils taken from the inner and outer parts of the canopy were found to be insignificant. According to soil depths, EC, calcium, potassium and sodium contents showed significant differences at $p<0.01$, and nitrogen and magnesium contents at p<0.05 probability level. On the other hand, it was determined that there were no significant changes in pH, lime, organic matter and phosphorus contents depending on soil depth.

It was determined that the pH values, lime, calcium, potassium and magnesium contents of the soil inner and outer of the canopy of Russian thistle varied between 7.93-8.19%, 8.39-10.81%, 4.33-5.24%, 0.21-0.44% and 0.32-0.44%, respectively (Table 2). Accordingly, soil samples taken from the inner parts of the canopy were found to have higher lime, potassium and magnesium contents compared to the outer parts of the canopy, while their pH and calcium contents were found to be lower. When the important parameters based on depth were examined, nitrogen (0.0028%) was found to be the highest at 0-20 cm, calcium (5.27%) and magnesium (0.41%) at 20-40 cm, EC (1.70), potassium (0.43%) and sodium (0.48%) at 40-60 cm soil depths (Table 2.).

Table 1. Variance analysis table of the examined features

Sources of Variation	F values and significance									
	pH	EC	Lime	OM	N	Ca	K	Mg	Na	P
Inner/outer of canopy (C)	5.3^{*}	0.02^{ns}	11.88^{**}	0.18^{ns}	0.00^{ns}	37.44^{**}	110.36^{**}	80.01^{**}	2.82^{ns}	2.06^{ns}
Soil depth (D)	2.9^{ns}	11.91^{**}	3.06^{ns}	2.57^{ns}	4.08^{*}	55.15^{**}	24.14^{**}	5.77^{*}	12.49^{**}	2.44^{ns}
C x D int.	1.1^{ns}	1.87^{ns}	2.21^{ns}	0.86^{ns}	0.39^{ns}	41.00^{**}	18.69^{**}	10.89^{**}	3.32^{ns}	2.52^{ns}

*p < 0.05, **p < 0.01, ns: non significant

The complex interactions of plant species, atmosphere, water and biological activities in the soil cause significant changes in soil properties (Tiedemann & Klemmedson, 1973; Charley & West, 1975; Schlesinger et al., 1996; Zheng et al., 2008). As a result of the mineralization and decomposition of organic matter, elements such as magnesium, potassium and calcium in the structure of organic matter pass into the soil and increase the amount of nutrients for plants (Gençtan, 2012; Karakuş & Keskin, 2017). In addition, a study by Parlak et al. (2012) reported that total nitrogen, cation exchange capacity, available phosphorus, calcium, magnesium, potassium and sodium amounts were higher in the soils located inner the plant canopy than in the soils outer the canopy. It is observed that plants improve the physical and chemical properties of soils and make a significant contribution to their productivity.

It has been reported that the chemical and physical properties of the soil taken from different depths (0-30 and 30-60 cm) inner and outer of the canopy of *Salsola arbusculiformis* changed significantly. EC, pH, organic carbon, potassium, sodium, nitrogen and water holding capacity of the soil inner of the canopy of *Salsola arbusculiformis* were found to be higher. It has also been reported that the plant can be used impressively for the improvement of degraded pastures in desertified and arid regions (Asaadi et al., 2014). The potassium content from the data obtained in this study is consistent with the results we obtained, but other parameters were different. This may be due to different plant species and soil characteristics. In a study, it was determined that the organic matter and EC values inner of the canopy were higher than outer of the canopy. On the other hand, it was found that there was no significant difference in pH values inner and outer of the canopy (Zheng et al., 2008).

Table 2. pH, EC, N, Ca, K, Mg, Na, and P values of soils at different depths of inner/outer of the plant canopy

Soil depth (cm)	Inner canopy	Outer canopy	Soil depth Avg.	Inner canopy	Outer canopy	Soil depth Avg.
	pH (1:2.5^{-1})			EC (dS m^{-1})		
0-20	7.73	8.17	7.95	1.57	1.77	1.66 a
20-40	8.23	8.27	8.25	1.33	1.23	1.28 b
40-60	7.83	8.13	7.98	1.77	1.63	1.70 a
Inner/outer canopy avg.	7.93 b*	8.19 a		1.56	1.54	
	Lime (%)			Organic matter (%)		

0-20	8.77	8.03	8.40	0.15	0.14	0.14
20-40	12.60	8.27	10.43	0.13	0.13	0.13
40-60	11.07	8.87	9.97	0.14	0.15	0.15
Inner/outer canopy avg.	10.81 a	8.39 b		0.14	0.14	
		Nitrogen (%)			**Calcium (%)**	
0-20	0.0030	0.0027	0.0028 a	4.16 b	6.37 a	5.27 a
20-40	0.0017	0.0020	0.0018 b	4.16 b	6.15 a	5.41 a
40-60	0.0027	0.0027	0.0027 ab	4.15 b	3.20 c	3.68 b
Inner/outer canopy avg.	0.0024	0.0024		4.33 b	5.24 a	
		Potassium (%)			**Magnesium (%)**	
0-20	0.37 b	0.19 d	0.28 b	0.39 b	0.34 b	0.37 b
20-40	0.31 bc	0.21 d	0.26 b	0.47 a	0.35 b	0.41 a
40-60	0.64 a	0.22 cd	0.43 a	0.46 a	0.25 c	0.36 b
Inner/outer canopy avg.	0.44 a	0.21 b		0.44 a	0.32 b	
		Sodium (%)			**Phosphorus (%)**	
0-20	0.43	0.30	0.36 b	30.33	22.83	26.58
20-40	0.34	0.27	0.30 b	32.03	29.50	30.76
40-60	0.45	0.50	0.48 a	29.60	31.93	30.76
Inner/outer canopy avg.	0.40	0.36		30.66	28.09	

*The difference between means indicated by different letters is significant.

While the decrease in soil organic matter is very evident as depth increases inside of the canopy, it has been reported that organic matter decreases to lower amounts due to increasing depth outer of the canopy. It has been reported that EC value decreases as soil depth increases at the inner of the canopy, while EC value increases as soil depth increases at the outer of the canopy (Zheng et al., 2008). In the soil samples taken from the inner of canopy of the goat's wheat (*Atraphaxis spinosa* L.) plant, it was determined that the amount of magnesium, potassium and calcium was higher than that outer of the canopy, and the soil pH was lower. It was determined that the potassium, magnesium, sodium and phosphorus content varied depending on the depth of the soil (Karakuş & Keskin, 2017). Some properties of the soil were determined according to different soil depths (0-20, 20-40 and 40-60 cm) inner and outer of the canopy of the thorny saltwort (*Noaea mucronata*). According to the research results, it was determined that the calcium content and pH value of the soil taken from the outer of the canopy were higher than those taken from the inner of the canopy, and the potassium and magnesium content were lower. It has been determined that calcium and sodium contents vary according to soil depth (Temel & Keskin, 2019). These results support our current research. Plants play a critical role in ecosystem sustainability and soil protection. A significant amount of organic matter is added to the soil through the leaves and roots of plants. Leaves and roots added to the soil contribute to the improvement of soil structure (Demir & Keskin, 2016). In addition, plants improve the physical and chemical balances of the soil as well as its biological structure (Parlak et al., 2012).

While calcium, potassium and magnesium contents were significant at $p<0.01$ level in the interaction of inner/outer of canopy x depth, examined other parameters were found to be insignificant (Table 1.). Their inner/outer of canopy x depth interaction data are given in Figures 1, 2 and 3.

Calcium content was found to be slightly higher at 20-40 cm soil depth compared to 0-20 cm soil depth at the canopy inner area. However, the calcium content detected at 40-60 cm soil depth was obtained in similar amounts at 0-20 cm soil depth. On the other hand, it was determined that calcium content decreased as soil depth increased in the outer of the canopy area. This difference between the inner and outer of the canopy caused the interaction of the inner/outer of the canopy x depth to be significant (Figure 1.).

While there were no significant differences in the potassium contents of soils taken at different depths outer of the canopy, the potassium content of soils taken inner of the canopy decreased at 20-40 cm compared to the 0-20 cm soil depth, but increased again at 40-60 cm. This difference between the inner and outer of the canopy caused the interaction of the inner/outer of the canopy x depth to be significant (Figure 2.).

It was determined that there was no significant change in the magnesium content of the soil at 20-40 cm soil depth compared to 0-20 cm soil depth outer of the canopy, while there was a significant decrease in the magnesium content at 40-60 cm soil depth. On the other hand, there was an increase in magnesium content at 20-40 cm soil depth compared to 0-20 cm soil depth of the inner of the canopy, but this increase did not continue at 40-60 cm soil depth (Figure 3.).

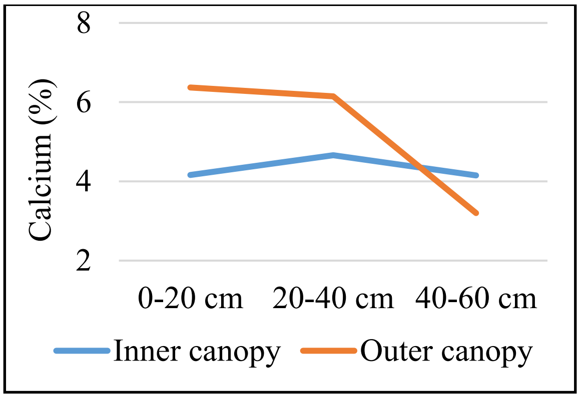

Figure 1. Changes in calcium content in the inner/outer of the plant canopy and at different depths of russian thistle

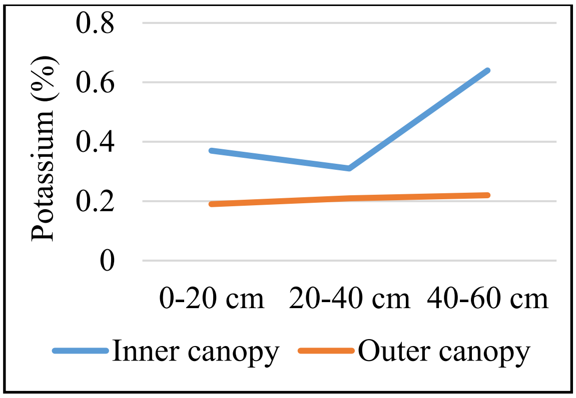

Figure 2. Changes in potassium content in the inner/outer of the plant canopy and at different depths of russian thistle

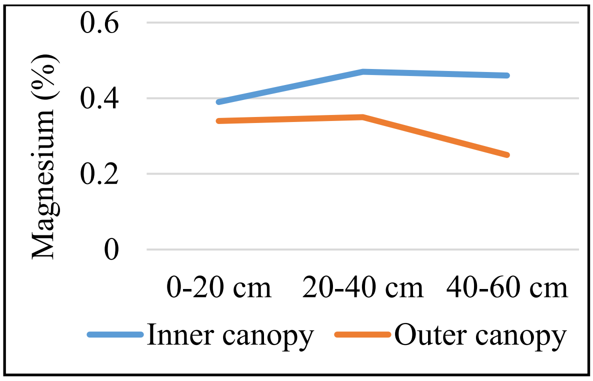

Figure 3. Changes in magnesium content in the inner/outer of the plant canopy and at different depths of russian thistle

4. Conclusion

As a result of the study, it was observed that the pH, lime, calcium, potassium and magnesium contents of the soils inner and outer of canopy of *Salsola ruthenica* differed significantly. Soil samples taken from the inner parts of the canopy were found to have higher lime, potassium and magnesium contents compared to the outer parts of the canopy, while pH and calcium contents were found to be lower. In particular, it is estimated that the decrease in soil pH at the inner of the canopy will contribute to the acidity of the soil and increase the uptake of plant nutrients in the soil. Soil EC, nitrogen, calcium, potassium, magnesium and sodium contents differed according to soil depth. While nitrogen was found to be high at 0-20 cm soil depth, calcium and magnesium were high at 20-40 cm and EC, potassium and sodium were high at 40-60 cm soil depth. In addition, calcium, potassium and magnesium were found to be significant in terms of inner/outer of canopy x depth interaction.

According to these results, it is seen that *Salsola ruthenica* can contribute to the improvement of basic soils by reducing soil pH in the canopy. It also shows that it can affect the chemical properties of the soil by increasing the percentage of lime, potassium and magnesium in the soil and decreasing the calcium.

References

Asaadi, A.M., Heshmati, G.A., & Dadkhah, A.R. (2014). The effects of shrubs *Salsola arbusculiformis* Drob. on soil chemical and physical characteristics in northeast rangelands of Iran. *Scientific Journal of Biological Sciences*, *3*(10), 1-8. https://doi.org/10.14196/sjbs.v3i10.1726.

Bremner, J.M, & Mulvaney, C.S. (1982). Nitrogen-Total. In: Page, A.İ (Eds), Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, 2nd Edition. American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin, 595-624. https://doi.org/10.2134/agronmonogr9.2.2ed.c31

Charley, J.L. & West, N.E. (1975). Plant-induced soil chemical patterns in some shrub-dominated semi-desert ecosystems of Utah. *Journal of Ecology*, 63(3), 945-963. https://doi.org/10.2307/2258613

Demir, U. & Keskin, B. (2016). Some soil properties in inside/outside of canopy and different soil depth of Gum tragacanth (*Astragallus gummifer* L.). *Journal of the Institute of Science and Technology*, *6*(4), 127-133. https://doi.org/10.21597/jist.2016624164.

Dimen, M. (2016). Seeds of russian tumbleweed (*Salsola ruthenica* ıljın.) germination physıology and determining of some emergency features. Master's thesis, Department of Plant Protection, Institute of Natural and Applied Sciences, Van Yüzüncü Yıl University.

Doran, J.W. & Parkin, T.B. (1994). Defining and assessing soil quality. In: Coleman, D.C., Bezdicek, D.F., Stewart, S.A. (Eds.). Defining soil quality for a sustainable environment, 35, 1-21. https://doi.org/10.2136/sssaspecpub35.c1.

Gençtan, T. (2012) Agricultural Ecology. Namık Kemal University. Textbook. General Publication: 6 Publication No:3, Tekirdağ.

Karakuş, B., & Keskin, B. (2017). Effects on some soil properties of soils in different deeps with internal and external canopy of goat's wheat (*Atraphaxis spinosa* L.) growing on erosion fields. *Adnan Menderes University Faculty of Agriculture Journal of Agricultural Sciences*, *14*(2), 13-17. https://doi.org/10.25308/aduziraat.305738.

Moerman, D.E. (1998). Native American Ethnobotany. Timber Press, Portland, OR.

Mosyakin, S. L. (1996). A taxonomic synopsis of the genus *Salsola* (*Chenopodiaceae*) in North America. *Annals of the Missouri Botanical Garden*, 83(3), 387-395. https://doi.org/10.2307/2399867

Nelson, D.W., & Sommers, L.E. (1982). Total carbon, organic carbon, organic matter, In: Page, A.İ (Eds), Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties, 2nd Edition. American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin, pp. 539-580. https://doi.org/10.2134/agronmonogr9.2.2ed.c29.

Özdoğan, N. (1976). Wind erosion and main measures to be taken in wind erosion areas. Soil and Water General Directorate (Toprak Su Genel Müdürlüğü) Publications, 306, Ankara. Yayınları, 306, Ankara.

Papendick, R.I., & Parr, J.F. (1992). Soil quality-the key to a sustainable agriculture. *American Journal of Alternative Agriculture*, *7*(1-2), 2-3. https://doi.org/10.1017/S088918930000 4343.

Parlak, M., Gökkuş, A., & Parlak, A. Ö. (2012). Influences of some shrubs on soil properties in the Çanakkale rangelands. *Soil Water Journal*, *1*(2), 88-98.

Rajakaruna, N., & Boyd, R.S. (2008). Edaphic Factor. In: Jorgensen, S.E., & Fath, B.D. (Eds.), General Ecology. Vol. [2] of Encyclopedia of Ecology, 5 vols. pp. 1201-1207, Oxford: Elsevier.

Rhoades, J.D. (1982). Soluble Salts. In: Page, A.L. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. 2nd Edition. The American Society of Agronomy, Inc., Soil Science Society of America, Inc pp. 167-179. https://doi.org/10.2134/agronmonogr9.2.2ed.c10.

Sağlam, M.T. (1994). Chemical Analysis Methods of Soil and Water. Trakya University Tekirdağ Faculty of Agriculture Publication No; 189, Supplementary Textbook No, 5.

Sevim, Z. (1999). Wind Erosion in Aralık-Iğdır. Republic of Turkey Prime Ministry General

Directorate of Rural Services Rural Services Research Institute, Erzurum.

Schlesinger, W.H., Raikes, J.A., Hartley, A.E., & Cross, A.F. (1996). On the spatial pattern of soil nutrients in desert ecosystems. *Ecology*, *77*(2), 364-374. https://doi.org/10.2307/2265615.

Schoenholtz, S. H., Van Miegroet, H., & Burger, J. A. (2000). A review of chemical and physical properties as indicators of forest soil quality: challenges and opportunities. Forest ecology and management, 138(1-3), 335-356. https://doi.org/10.1016/S0378-1127(00)00423-0.

Temel, S., & Keskin, B. (2019). Effect of thorny saltwort (*Noaea mucronata*) growing in the wind erosion field on soil's some chemical properties. *Atatürk University Journal of Agricultural Faculty*, *50*(2), 167-173. https://doi.org/10.17097/ataunizfd.487883.

Tiedemann, A.R., & Klemmedson, J. O. (1973). Effect of mesquite on physical and chemical properties of the soil. *Journal of Range Management*, *26*(1), 27-29.

Wagner, W.L., Herbst, D.R., & Sohmer, S.H. (1990). Manual of the flowering plants of Hawai'i. University of Hawaii Press.

Zheng, J., He, M., Li, X., Chen, Y., & Liu, L. (2008). Effects of *Salsola passerina* shrub patches on the microscale heterogeneity of soil in a montane grassland, China. *Journal of Arid Environments*, *72*(3), 150-161. https://doi.org/10.1016/j.jaridenv.2007.05.010.

Zúñiga, F., Dec, D., Valle, S.R., Thiers, O., Paulino, L., Martínez, O., Seguel, O., Casanova, M., Pino, M., Horn, R., & Dörner, J. (2019). The waterlogged volcanic ash soils of southern Chile. A review of the "Ñadi" soils. *Catena*, *173*, 99-113. https://doi.org/10.1016/j.catena.2018.10.003.

Turkish Journal of Range and Forage Science, 2025, 6(1): 8-17
doi: 10.51801/turkjrfs.1628335

Research

Turkish Journal of Range and Forage Science
https://dergipark.org.tr/tr/pub/turkjrfs

The Effect of Different Withering Times and Different Additives on the Feed Value of Alfalfa Silage

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A R T I C L E I N F O

Received *28/01/2025*
Accepted *05/03/2025*

Keywords:

Fermentation,
pH,
nutrient content,
physical properties

A B S T R A C T

The study was conducted to determine the effects of different withering time and additives on some physical and chemical parameters and feed value of alfalfa (Medicago sativa) silage. In the study, Bilensoy alfalfa variety, 3 different withering times (0, 12 and 24 hours) and 6 different additives (control, 4% cracked barley, 4% cracked wheat, 4% cracked corn, 4% wheat bran and 2% sucrose) were added and 18 subjects were examined. Silages were formed in the laboratory using vacuum bags (25 × 35 cm in size, 110 micron thickness) and vacuum machine, and the packages were kept at room temperature for 2 months for silage maturation. DLG scoring method was used to determine the physical quality of matured silages. For chemical quality and feed value; dry matter (DM), pH, crude protein (CP), crude ash (CA), acid detergent fibre (ADF) and neutral detergent fibre (NDF) values of the silage samples were determined, Fileg score, total digestible nutrients (TDN), dry matter intake (DMI), digestible dry matter (DDM), net energy lactation (NEL) and relative feed value (RFV) were calculated. The prolonged withering period decreased the CP in alfalfa silage, while DLG classification, pH, Fleig score, DM, CA, ADF and NDF increased significantly. The effect of additives added to alfalfa silage on DLG classification was found to be insignificant, but withering increased DLG score significantly. It was determined that the additives decreased, pH, CP, NDF and ADF ratios, increased Fleig score and significantly improved feed value parameters compared to the control group. Withering significantly increased all calculated feed value parameters. As a result, in terms of optimum feed value and alfalfa silage quality, 24 h withering and 4% cracked corn addition can be recommended compared to the other treatments compared.

1. Introduction

Alfalfa is a difficult plant to silage due to its high protein content, low water-soluble carbohydrate level and high buffer capacity (Tatli Seven et al., 2021). The relationship between the withering time and the use of additives in alfalfa silage is critical, especially to optimize fermentation quality and increase nutritional value. The withering time affects the moisture content and thus the fermentation process. Tremblay et al. (2014), who investigated the effect of mowing alfalfa plants in the afternoon and withering until they contained about 35% DM by wide spreading on silage

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fermentation characteristics, reported that withering increased the non-structural carbohydrate content of alfalfa, was well preserved during fermentation, and the silage exhibited lower pH, higher lactic acid concentration, lower volatile fatty acids and NH3-N contents. Dumlu Gül et al. (2015) reported that 12 h withering period and 10% barley addition could significantly improve the physical properties and pH of alfalfa silage. Tremblay et al. (2014), who studied the effect of harvesting alfalfa plants in the afternoon and withering until about 35% DM content by wide spreading on silage fermentation characteristics, reported that withering increased the non-structural carbohydrate content of alfalfa, was well preserved during fermentation, and the silage exhibited lower pH, higher lactic acid concentration, lower volatile fatty acids and NH3-N contents. Dumlu Gül et al. (2015) reported that 12 h withering period and 10% barley addition could significantly improve the physical properties and pH of alfalfa silage. Li et al. (2016) studied the effects of various chemical additives (sucrose, potassium citrate, sodium carbonate, acetic acid, formic acid, propionic acid) on the fermentation quality of alfalfa harvested at high moisture content and reported that potassium citrate and sucrose improved fermentation quality especially when alfalfa was wilted to 30% DM content. This suggests that the withering period should be optimized to increase the effectiveness of the additives, so that the overall quality of the silage can be improved.

It is common to use additives to improve the fermentation process of forage crop silages with high protein and mineral content but low carbohydrate content. Research has shown that specific additives can significantly improve fermentation quality, chemical composition and microbial population during silage production. Wang et al. (2024) reported that the addition of Lactobacillus plantarum as a silage additive to sand acacia (Caragana korshinskii Kom), a legume shrub form, decreased the pH and increased the lactic acid content of silage, while the addition of cellulase and xylenase increased the degradability of structural carbohydrates and supported fermentation quality. In addition, formic acid was reported to improve fermentation quality by supporting the stabilization of red clover silage (Rinne et al., 2024).

Carbohydrate sources such as cereal grains, sucrose, glucose and molasses are used in the production of legume silages because they are economical and improve fermentation quality. Zi et al. (2022) reported that sucrose, glucose or molasses (10g/kg wet weight) increased the lactic acid level and decreased the pH in the silage of stylo (Stylosanthes guianensis), a legume plant, thus increasing silage stability. Similarly, Aydın et al. (2023) reported that the addition of lactic acid bacteria and 1.5% sucrose to alfalfa silage significantly decreased pH compared to the lactic acid bacteria addition group. It is also known that barley (5%) used as an additive in alfalfa silage production significantly improves silage quality (Acar and Bostan, 2016).

Nowadays, there are also a number of studies on the use of bran in legume plant silages (Tian et al., 2018; Çotuk and Önenç, 2017). Tian et al. (2018), who evaluated the effects of lactic acid inoculants on silage quality in alfalfa and wheat bran (0, 10, 15 and 20%) mixture silages, reported that DM content increased, pH and ammonia nitrogen decreased as wheat bran ratio increased, and bran was effective in terms of choosing the right inoculant in the fermentation process of alfalfa silage. In addition, Çotuk and Önenç (2017) reported that the addition of 10% bran significantly increased the quality classification of alfalfa silage in terms of flieg score and physical evaluation score, significantly increased the number of lactobacilli and decreased pH. The researchers reported that the Flieg score of alfalfa silage with no additive and 10% bran additive, which were wilted for 3 hours after harvest, were 61.39 (good quality) and 81.70 (very good quality), respectively. It is a necessary condition for sustainable animal husbandry that the additives used during the silage production of plant species such as alfalfa, which are difficult to silage, should be met from the farm's own production or be economical. The aim of this study was to evaluate the effects of different withering time and additives (cracked barley, cracked wheat, cracked corn, wheat bran and sucrose) on some physical and chemical parameters and feed value of alfalfa silage.

2. Material and Method

Bilensoy alfalfa (*Medicago sativa*) variety was used as silage material in the study. The alfalfa plant used in the experiment was obtained from the application area of Isparta University of Applied Sciences, Faculty of Agriculture. The development of the plant from sowing to harvest time was followed regularly and harvesting was carried out on June 25, 2020 at the middle of flowering. In the study, 3 different withering times (0, 12 and 24 h) were applied after harvest. For each withering period, 1 control (no additive) and 5 experimental groups (4% crushed barley, 4% crushed wheat, 4% crushed maize, 4% wheat bran and 2% sucrose) were formed. The additives consisted of crushed cereals, sucrose or wheat bran used in silage production of plants with high protein content (Zi et al., 2022; Tian et al., 2018; Acar and Bostan, 2016). Withering times of alfalfa were determined in parallel with the studies (Besharati et al., 2000; Acar and Bostan, 2016; Dumlu Gül et al., 2015). The study was carried out on 18 study subjects in a 3 x 6 factorial experimental design. The subjects examined in the study were designed with 3 replicates and a total of 54 silages were formed. The withering process was carried out under natural conditions in the field after harvest (Yang et al., 2022). The additives used in the experiment were proportioned according to the fresh weight of the plant (Li et al., 2016). Average DM (36.24%), CP (22.02%), CA (13.01%), NDF (42.18%) and ADF (28.37%) ratios were determined in alfalfa samples taken before silage. The silage samples of each experimental group were first weighed, additives were added and mixed homogeneously by hand. The silage samples were filled into vacuum bags (25 × 35 cm in size, 110 micron thickness) of approximately 800 g and the air in the bags was removed with the help of an industrial vacuum machine (Ahsan, 2023). The bags were sealed to provide anaerobic environment and the samples were kept at room temperature for 2 months.

Following the maturation period, silage samples of each group were opened and physical quality analyses (color, odor and structure) were performed by three researchers using the DLG (Deutsche Landwirtschafts - Gesellschaft) silage evaluation key (Table 1) and the mean scores were taken (Table 2) (DLG, 1987).

Table 1. DLG silage evaluation key

	Observation	Score
Odor	No buttery acid smell, slightly sour, fruity and bread-like odor	14
	A slight buttery odor, strong sour odor or musty odor	8
	Moderate buttery odor, strong musty odor	4
	Strong buttery odor and ammonia smell	2
	Rotten or foul and strong musty odor	0
Structure	Leaf and stem structure normal	4
	The structure of the leaves is a bit distorted	2
	Leaves and stems have a markedly deformed structure, slightly moldy	1
	Leaves and stems rotten, heavily moldy and heavily soiled	0
Color	Green forage color (slightly brownish in wilted silage)	2
	Yellow or dusky brown	1
	The color has changed a lot, light yellow or very dark	0

Table 2. Total DLG (Deutsche Landwirtschafts - Gesellschaft) score evaluation criteria.

Total DLG Score	Silage Quality Class	Average Nutrient Loss
18-20	Very Good Quality	10-15%
14-17	Good Quality	15-20%
10-13	Medium Quality	20-25%
5-9	Low Quality (Poor Quality)	25-50%
0-4	Very Low Quality (Degraded)	≥50%

In the study, pH was determined by modifying the method of Akbay et al. Twenty g of silage sample from each replicate was treated with 180 ml of distilled water for 2-3 min in a mixer and filtered through a double layer of cheesecloth. The pH levels of the silage filtrates were measured using a digital pH meter (Thermo Orion Star, serial no: B39604). DM, CA and CP analyses of the silage samples of the groups were determined according to the method reported in AOAC (2000), while NDF and ADF analyses were determined using an automatic analyzer (ANKOM 220 Fiber Analyzer, serial no: # A220220035) according to the method reported in Van Soest et al., (1991). NDF solution was prepared by adding 120 g FND20C/1 and 20 ml triethylene glycol FND20C/2 to 1.8 liters of distilled water and stirred with a magnetic stirrer (Wisestir MSH-20A, Serial no: 0400985129J040) until dissolved and completed with 2 liters of distilled water. ADF solution was prepared by dissolving 40 g CTAB (Cetyltrimethylammoniumbromide) in 2 liters of 1.0 normal H_2SO_4 with the same magnetic stirrer. The following formulae adapted from various sources were used to calculate net energy lactation (NEL), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and total digestible nutrients (TDN) (NRC, 2001; Horrocks and Vallentine, 1999; Van Soest, 1994; USDA, 1980; Rohweder et al., 1978). Flieg score was calculated according to the method reported by Moselhy et al. (2015).

$$\text{Flieg score} = 220 + (2 \times \text{DM (\%)} - 15) - (40 \times \text{pH value})$$

$$\text{NEL (Mcal/kg)} = (1.044 - (0.0119 \times \text{ADF})) \times 2.205$$

$$\text{DDM (\%)} = 88.9 - (0.779 \times \text{ADF}$$

$$\text{DMI (\% body weight)} = 120 \div \text{NDF}$$

$$\text{RFV} = \text{DDM (\%)} \times \text{DMI (\%)} \times 0.775$$

$$\text{TDN} = (-1.291 \times \text{ADF}) + 101.35$$

Relative feed value is a criterion used in the evaluation and marketing of roughages and <75 indicates poor quality; 75-86 indicates 4th quality; 87-102 indicates 3rd quality; 103-124 indicates 2nd quality; 125-151 indicates good quality and >151 indicates 1st quality (Kılıç and Abdiwali, 2016). The quality classification of the silages was made according to the Flieg score sheet (Moselhy et al., 2015) shown in Table 3. The data of the experiment were subjected to analysis of variance using SAS (1998) computer programme according to factorial completely randomized design. When significant differences were found as a result of statistical analysis, Duncan test was applied at 5% significance level for comparison of means.

Table 3. Flieg score sheet

Score range	Silage Quality Class
20 points and below	Very poor quality
21-40 points	Low quality
41-60 points	Medium quality
61-80 points	Good quality
81 points and above	Very good quality

3. Results and Discussion

In the study, withering significantly increased the DLG score (Table 4) of alfalfa silage ($p<0.05$), while additives and additive x withering interaction were statistically insignificant. When the mean values of the withering times were analyzed, the DLG score was determined as 18.44 in alfalfa silages made without withering, while the DLG scores were determined as 19.46 and 19.70 after 12 and 24 hours of withering, respectively. When the mean values of the additives were analyzed, they were statistically insignificant and the DLG scores obtained varied between 18.59 and 19.92. The DLG scores determined in the experiment were classified as very good quality. Dumlu Gül et al. (2015) reported that harvest time (early and late flowering), withering (12 h) and addition of additives (5% molasses and 10% cracked barley) positively affected the physical properties of silage. Acar and Bostan (2016) also reported that the physical quality of alfalfa silage withered for 24 h and 5% barley added was in the very good quality class (19 points). These studies are in parallel with the findings of the research in terms of withering time.

Table 4. Effect of withering time and different additives on the physical properties of alfalfa silage

Additive	Odor				Color			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	

Control	12.44	13.44	13.78	13.22	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Cracked Barley	11.89	13.67	13.89	13.15	1.43^{b}	2.00^{a}	2.00^{a}	1.81 b
Cracked Wheat	13.44	13.56	13.22	13.41	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Cracked Corn	13.78	14.00	14.00	13.93	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Wheat Bran	12.67	12.78	14.00	13.15	1.30^{b}	2.00^{a}	2.00^{a}	1.77 b
Sucrose	13.67	13.56	14.00	13.74	2.00^{a}	2.00^{a}	2.00^{a}	2.00 a
Means	12.99 b	13.50 ab	13.81 a		1.79 b	2.00 a	2.00 a	
	Wit: *; Add: ns; WxA: ns				Wit: **; Add: **; WxA: **			
Additive	Structure				DLG			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	3.44	3.78	4.00	3.74	17.89	19.22	19.78	18.96
Cracked Barley	2.89	4.00	4.00	3.63	16.22	19.67	19.89	18.59
Cracked Wheat	4.00	4.00	3.67	3.89	19.44	19.56	18.89	19.30
Cracked Corn	4.00	4.00	4.00	4.00	19.78	20.00	20.00	19.93
Wheat Bran	3.67	4.00	3.67	3.78	17.67	18.78	19.67	18.70
Sucrose	4.00	4.00	4.00	4.00	19.67	19.56	20.00	19.74
Means	3.66 b	3.96 a	3.89 ab		18.44 b	19.46 a	19.70 a	
	Wit: *; Add: ns; WxA: ns				Wit: **; Add: ns; WxA: ns			

Wit: Withering; Add: Additive; ns: Non significant; *: $P<0.05$; **: $P<0.01$

The effects of withering time and different additives on pH, some nutrient ingredients, Fleig score and quality classification of alfalfa silage are shown in Table 5. In the study, withering time and additive use significantly increased the DM ($p<0.01$) and decreased the pH ($p<0.01$) of alfalfa silages. The effects of withering time and additive treatments on ratios of CP, CA, DM, NDF, ADF and NEL level were statistically significant at 1% level. It was determined that the effect of withering time and additive interactions on DM, CA, ADF and NEL was at $p<0.01$ level, while it was at $P<0.05$ level on CP.

Table 5. Effect of withering time and different additives on pH, DM, Flieg score, CP, CA, ADF, NDF and NEL of alfalfa silage, % in DM

Additive	DM				pH			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	31.37^{ı}	38.57^{e}	43.60^{b}	37.85 c	4.82^{a}	4.81^{a}	4.83^{a}	4.82 a
Cracked Barley	35.70^{gh}	42.19^{c}	46.26^{a}	41.38 a	4.73^{b-d}	4.74^{bc}	4.75^{b}	4.74 c
Cracked Wheat	37.24^{f}	40.79^{d}	45.87^{a}	41.29 a	4.64^{g}	4.70^{d-f}	4.70^{d-f}	4.68 d
Cracked Corn	36.19^{fg}	42.47^{c}	46.23^{a}	41.63 a	4.6 ^{h}	4.59^{hı}	4.56^{ı}	4.58 e
Wheat Bran	35.90^{gh}	41.69^{cd}	45.99^{a}	41.22 a	4.74^{b-d}	4.75^{bc}	4.83^{a}	4.77 b
Sucrose	34.95^{h}	41.47^{cd}	44.41^{b}	40.27 b	4.67^{fg}	4.68^{ef}	4.70^{c-e}	4.69 d
Means	35.24 c	41.20 b	45.39 a		4.70 b	4.71 b	4.73 a	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: **			
Additive	CP				Fleig			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	23.57^{a}	23.00^{b}	22.50^{bc}	23.02 a	74.8^{h}	89.6^{g}	98.9^{e}	87.8 d
Cracked Barley	22.47^{b-d}	22.10^{c-e}	21.90^{c-f}	22.15 b	87.2^{g}	99.7^{e}	107.2^{bc}	98.0 c
Cracked Wheat	22.50^{bc}	22.03^{c-e}	21.97^{c-e}	22.16 b	93.7^{f}	98.5^{e}	108.6^{b}	100.3 b
Cracked Corn	21.60^{e-g}	21.83^{d-f}	21.20^{gh}	21.54 c	93.1^{f}	106.5^{b-d}	115.2^{a}	104.9 a
Wheat Bran	22.40^{b-d}	22.80^{b}	22.90^{b}	22.70 a	87.4^{g}	98.5^{e}	103.8^{d}	96.6 c
Sucrose	21.10^{gh}	21.33^{f-h}	20.83^{h}	21.09 d	88.2^{g}	100.7^{e}	105.2^{cd}	98.0 c
Means	22.27 a	22.18 a	21.88 b		87.4 c	98.9 b	106.5 a	
	Wit: **; Add: **; WxA: *				Wit: **; Add: **; WxA: **			
Additive	NDF				ADF			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	36.97	38.30	37.73	37.66 a	24.73^{cd}	26.69^{a-c}	28.51^{a}	26.64 a

Cracked Barley	35.50	37.33	38.00	36.94 ab	25.53^{b-d}	26.04^{b-d}	25.57^{b-d}	25.71 ab
Cracked Wheat	35.67	37.70	37.37	36.91 ab	25.01^{b-d}	25.39^{b-d}	24.87^{b-d}	25.09 b
Cracked Corn	34.30	35.80	37.10	35.73 c	20.53^{g}	25.06^{b-d}	25.15^{b-d}	23.58 c
Wheat Bran	36.43	37.97	38.40	37.60 a	24.27^{de}	26.79^{ab}	28.33^{a}	26.46 a
Sucrose	36.07	36.43	36.77	36.42 bc	21.84^{fg}	22.59^{ef}	24.27^{de}	22.89 c
Means	35.82 b	37.26 a	37.56 a		23.65 c	25.43 b	26.12 a	
	Wit: **; Add: **; WxA: ns				Wit: **; Add: **; WxA: **			
Additive	NEL				CA			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	1.65^{d}	1.60^{ef}	1.55^{g}	1.60 c	12.60^{b}	12.50^{b-d}	12.00^{g-j}	12.36 b
Cracked Barley	1.63^{de}	1.62^{de}	1.63^{de}	1.62 bc	12.27^{d-g}	11.97^{h-j}	11.97^{h-j}	12.06 c
Cracked Wheat	1.65^{d}	1.64^{de}	1.65^{d}	1.64 b	12.20^{e-h}	12.40^{b-e}	12.17^{e-i}	12.25 b
Cracked Corn	1.76^{a}	1.64^{de}	1.64^{de}	1.68 a	11.83^{j}	12.10^{f-j}	11.90^{ij}	11.94 c
Wheat Bran	1.67^{cd}	1.60^{ef}	1.56^{fg}	1.60 c	12.30^{c-f}	13.17^{a}	12.53^{bc}	12.66 a
Sucrose	1.73^{ab}	1.71^{bc}	1.67^{cd}	1.70 a	12.20^{e-h}	12.17^{e-i}	11.83^{j}	12.06 c
Means	1.68 a	1.64 b	1.62 c		12.23 b	12.38 a	12.07 c	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: **			

DM: Dry mater; CP: Crude protein; CA: Crude ash; ADF: Acid detergent fiber; NDF: Neutral detergent fiber; NEL: Net energy lactation (Mcal/kg); Wit: Withering; Add: Additive; ns: Non significant; *: P<0.05; **: P<0.01

In the study, it was determined that the addition of additives and both withering times (12 and 24 h) significantly increased the DM content of alfalfa silage (P<0.01) and the interactions between them were significant. Both withering times and additives had a positive effect on DM in alfalfa silages, but fluctuations and intersections in the values caused the withering time x additive interaction to be significant. The lowest value was obtained from 0 h x control combination and the highest values were obtained from 24 h x cracked barley, 24 h x cracked wheat, 24 h x cracked corn and 24 h x wheat bran combinations. Similar to the findings of this study, the DM content of alfalfa silage withered for 12 h decreased significantly and the interaction between the withering time and the addition of additives (barley, molasses) was found to be significant (Dumlu Gül et al., 2015). Researches evaluating the effects of various additives added to alfalfa silage on silage quality (Li et al., 2016) and feed value (Mariotti et al., 2020) preferred to wither the DM of alfalfa to 30% and 38%, respectively, which supports the findings of the study.

In the study, prolonging the withering time significantly increased the silage pH, but all additives significantly decreased the silage pH compared to the control group (4.82). However, the lowest pH levels were recorded in the 4% crushed corn, 4% crushed wheat and 2% sucrose supplemented groups with 4.58, 4.68 and 4.69, respectively. Terms related to the withering time x additive interaction of pH values are shown as pH values obtained as a result of the applications change between 4.56-4.83. In general, additive treatments increased pH values depending on withering times in alfalfa, while the decrease in pH value as a result of cracked corn treatment caused the interaction to be significant. However, Dumlu Gül et al. (2015) reported that both withering and additive treatments decreased pH. While the results obtained by the researchers from the additive application were in agreement with our findings, the results obtained as a result of withering were inconsistent with our findings. All treatments were found to be statisticaly significant in terms of Fleig score (p<0.01). While both withering times increased the Flieg score, all additive groups had higher Flieg scores compared to the control group. Withering time x additive interaction was found to be significant in terms of fleg score, withering times and additive treatments increasing fleg score value. Although this increase generally showed a linear trend, the values calculated in additive treated silages had different increase rates depending on the withering time. In the present study, fleg score values varied between 74.8 and 115.2, the lowest value was determined in the 0 h x control combination, and the highest value was determined in the 24 h x cracked corn combination. In parallel with the findings of present study, it was reported that the Flieg scores of alfalfa silage were 90.87 (very good quality) and 61.39 (good quality) at the end of twenty-four hours (Besharati et al., 2000) and three hours (Çotuk and Önenç, 2017) withering, respectively. Naturally, Fleig score increases as the DM value of the silage sample increases and pH value decreases. The Fleig score results of the study groups are in parallel with the data. Withering of alfalfa for 24 h significantly decreased the CP and CA ratios of the silage and increased the ADF and NDF ratios. CP varied between 21.88% and 22.27%, CA between 12.06% and 12.38%, NDF between 35.82% and 37.56% and ADF between 23.65% and 26.11% according to withering periods. It was determined that the addition of cracked wheat, cracked corn and sucrose to alfalfa silage significantly decreased silage ADF, while the addition of cracked corn and sucrose significantly decreased silage NDF. According to the results of additives to alfalfa silage, CP varied between 21.08% and 23.02%, CA between 11.94% and 12.66%, NDF between 35.71% and 37.66% and ADF between 22.89% and 26.64%.

There is statistical significance in the withering time x additive interaction of CP, CA and ADF ratios. This situation is due to the differences in the increase and decrease rates of the values in the silage samples treated with additives depending on the withering time of CP, CA and ADF properties. The intersection points caused the withering time x additive interaction to be significant. In this context, Aydın et al. (2023) reported that the addition of lactobacilli and 1.5% sucrose had no effect on the CP content of alfalfa silage, whereas Çotuk and Önenç (2017) stated that the inclusion of 10% bran increased the CP level of silage. Furthermore, Mariotti et al. (2020) found that the addition of increasing levels of whey (7.5%, 15%, and 30%) to withered alfalfa (38%) significantly reduced the DM, ADF, and NDF contents of the silage. These findings highlight the complex interactions between withering time and additive effects on silage composition, further emphasizing the significance of the observed statistical interactions. It is clear that the effect of withering and additive on silage DM content may be related to their effects on fermentation, as well as the DM content of the additive used is also related to silage DM. As a matter of fact, in the present study, withering and additive interactions were found to be significant in terms of DM and ADF values, and the addition of 4% crushed cereals to alfalfa silage increased DM content and decreased ADF and NDF values significantly compared to the control group. The fact that the interaction between withering time and additive was insignificant in terms of NDF value is similar to Dumlu Gül et al. (2015) who applied 12 hours of withering to alfalfa silage. Acar and Bostan, (2016) who applied withering to alfalfa (24 hours) and those who did not (Aydın et al., 2023; Tian et al., 2018; Çotuk et al., 2017) reported that the addition of additives (molasses, barley, lactobacilli, bran, whey and sucrose) significantly decreased silage ADF and NDF ratios, supporting the findings of the present study.

The effects of withering time and different additives on the feed value of alfalfa silage are shown in Table 6. In terms of the analyzed feed value parameters (TDN, DMI, DDM and RFV), withering time and additive treatments were statistically significant at 1% level. It was determined that the effect of withering time x additive on TDM and DDM values was significant at P<0.01 level, while the effect on DMI and RFV values was insignificant. While the increase in withering time decreased the feed value parameters, it was observed that the additive treatments except wheat bran addition had better values compared to the control group. It was determined that the highest values in terms of TDN, DDM and RFV were obtained in the cracked corn and sucrose added groups, while the cracked corn added group had the highest value in terms of DMI.

Table 6. Effect of withering time and different additives on feed value of alfalfa silage, % in DM

Additive	TDN				DMI			
	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	69.42^{de}	66.89^{e-g}	64.54^{g}	66.95 c	3.25	3.13	3.18	3.18 c
Cracked Barley	68.40^{d-f}	67.73^{d-f}	68.33^{d-f}	68.15 bc	3.38	3.22	3.16	3.25 bc
Cracked Wheat	69.06^{d-f}	68.58^{d-f}	69.24^{d-f}	68.95 b	3.37	3.18	3.21	3.25 bc
Cracked Corn	74.84^{a}	69.00^{d-f}	68.88^{d-f}	70.90 a	3.50	3.35	3.23	3.36 a
Wheat Bran	70.02^{cd}	66.77^{fg}	64.78^{g}	67.19 c	3.29	3.16	3.13	3.19 c
Sucrose	73.15 ab	72.19 bc	70.02 cd	71.78 a	3.33	3.29	3.26	3.29 b
Means	70.81 a	68.53 b	67.63 c		3.35 a	3.22 b	3.20 b	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: ns			
Additive	DDM				RFV			

	Withering time			Means	Withering time			Means
	0 h	12 h	24 h		0 h	12 h	24 h	
Control	69.63^{de}	68.11^{e-g}	66.69^{g}	68.14 c	175.3	165.4	164.4	168.4 c
Cracked Barley	69.02^{d-f}	68.61^{d-f}	68.98^{d-f}	68.86 bc	180.9	171.1	168.9	173.7 b
Cracked Wheat	69.42^{d-f}	69.12^{d-f}	69.52^{d-f}	69.35 b	181.0	170.5	173.0	174.9 b
Cracked Corn	72.90^{a}	69.38^{d-f}	69.31^{d-f}	70.53 a	197.9	180.4	173.7	184.0 a
Wheat Bran	70.00^{cd}	68.03^{fg}	66.83^{g}	68.28 c	178.7	166.6	161.9	169.1 c
Sucrose	71.89^{ab}	71.30^{bc}	70.00^{cd}	71.06 a	185.4	182.0	177.1	181.5 a
Means	70.48 a	69.09 b	68.55 c		183.2 a	172.7 b	169.8 b	
	Wit: **; Add: **; WxA: **				Wit: **; Add: **; WxA: ns			

TDN: Total digestible nutrients (%); DMI: Dry matter intake (% body weight); DDM: Digestible dry matter (%); RFV: Relative feed value; Wit: Withering; Add: Additive; ns: Non significant; *: $P<0.05$; **: $P<0.01$

In the literature, no study was found in which the effects of withering time and additives on the feed value of alfalfa silage were evaluated together. Acar and Bostan (2016) reported that molasses, barley or whey added to alfalfa silage withered for 24 hours improved the DDM, DMI, RFV and TDN of silage compared to the control group. In parallel with the research findings, Mariotti et al. (2020) reported that whey (15% and 30%) added to alfalfa wilted to 38% DM decreased NDF and ADF ratios while improving TDN and RFV values of silage.

4. Conclusion

It is clear that withering time and the water soluble carbohydrate content of the plant during the silage maturation process affect silage quality. Optimum withering time will provide a stable fermentation environment by balancing the water content, but prolonged withering time may lead to nutrient losses. In the study, it was observed that withering significantly increased the DLG score of alfalfa silage, but the interaction between additive addition and withering was insignificant in terms of DLG score. While the quality classification was high in the experimental groups, the interaction between withering time and additive was found to be significant in terms of NDF value. In particular, it was determined that 12 hours of withering time had no effect on pH, but 24 hours of withering time significantly decreased silage pH with the addition of additive. This may be due to the fact that prolonged withering improves the fermentation environment and increases the activity of lactic acid bacteria. In the study, the addition of 4% cracked wheat or cracked corn and 2% sucrose significantly decreased silage ADF and NDF values. However, ADF value was found to be significant while NDF value was found to be insignificant in terms of withering additive interaction. When all the results of the study were analyzed, it was observed that the prolongation of the withering period decreased the CP rate of alfalfa silage and significantly increased the DLG classification, Fleig score, DM ratio, pH, CA, ADF and NDF ratios. On the other hand, the additives decreased DLG classification, pH, CP, NDF and ADF ratios of alfalfa silage compared to the control group, increased Fleig score and CA ratio and significantly improved feed value parameters. As a result, it is seen that withering application is beneficial in alfalfa silage production to obtain better quality silage, while the addition of additives is important. In terms of withering time in alfalfa silage production, it was concluded that 24 hours of withering and 4% cracked corn addition were suitable for optimum silage quality and feed value parameters.

References

Acar, Z., & Bostan, M. (2016). Değişik doğal katkı maddelerinin yonca silajının kalitesine etkilerinin belirlenmesi. Anadolu Tarım Bilimleri Dergisi, 31(3), 433-440.

Ahsan, U. (2023). Effect of single or combined homo- and heterofermentative silage additives on the quality, nutritive val¬ue, and in vitro digestibility of ensiled wheat harvested at early dough stage of maturity. Mehmet Akif Ersoy University Jour¬nal of Health Sciences Institute, 11(2), 267-274.

Akbay, F., Günaydın, T., Arıkan, S. & Kızılşimşek, M. (2023) Performance of new lactic acid bacteria strains as inoculants on the microorganism composition during fermentation of alfalfa silage containing different dry matter content. Black Sea Journal of Agriculture, 6(4) 402-410.

AOAC (2000). Official methods of analysis of AOAC International. Association of Official Analytical Chemist, Washington DC.

Aydın, S. S., Denek, N., Avcı, M., Kırar, N., & Top, Ş. (2023). The effect of fermented natural lactic acid bacteria liquid and water-soluble carbohydrate admixture on alfalfa (Medicago sativa L.) silage fermentation quality, in vitro digestibility and methane production. Veterinary Journal of Mehmet Akif Ersoy University, 8(3), 172-178.

Besharati, M., Karimi, M., Taghizadeh, A., Nemati, Z., & Kaygısız, A. (2020). Improve quality of alfalfa silage ensiled with orange pulp and bacterial additive. Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi, 23(6), 1669-1677.

Çotuk, G. M., & Önenç, S. S. (2017). Yonca silajına kepek ve puding ilavesinin silaj fermantasyonu, aerobik stabilite ve in vitro sindirilebilirlik üzerine etkileri. Hayvansal Üretim, 58(1), 13-19.

DLG (1987). Bewertung von Grünfutter, Silage und Heu, Merkblatt, No:224, DLGVerlag, Deutschland. In: Karadeniz, E., & Saruhan, V. (2021). Mardin ekolojik koşullarında farklı ekim zamanlarında yetiştirilen ikinci ürün silajlık mısır (Zea mays L.) çeşitlerinin silaj özelliklerinin araştırılması. ISPEC Journal of Agricultural Sciences, 5(2), 275-289

Dumlu Gül, Z., Tan, M., Fayetörbay Kaynar, D., & Kharazmi, K. (2015). Effects of some additives, harvest stage and wilting on quality characteristics of alfalfa silage. Atatürk Üniversitesi Ziraat Fakültesi Dergisi, 46(2), 113-118.

Horrocks R. D., & Vallentine J. F. (1999) Harvested forages. Academic Press, London, UK. In: Ahsan, U. (2023). Effect of single or combined homo-and heterofermentative silage additives on the quality, nutritive value, and in vitro digestibility of ensiled wheat harvested at early dough stage of maturity. Mehmet Akif Ersoy University Journal of Health Sciences Institute, 11(2), 267-274.

Kılıç, Ü., & Abdiwali, M. A. (2016). Alternatif kaba yem kaynağı olarak şarapçılık endüstrisi üzüm atıklarının in vitro gerçek sindirilebilirlikleri ve nispi yem değerlerinin belirlenmesi. Kafkas Universitesi Veteriner Fakultesi Dergisi, 22(10.9775).

Li, P., Ji, S., Hou, C., Tang, H., Wang, Q., & Shen, Y. (2016). Effects of chemical additives on the fermentation quality and N distribution of alfalfa silage in south of China. Animal Science Journal, 87(12), 1472-1479.

Mariotti, M., Fratini, F., Cerri, D., Andreuccetti, V., Giglio, R., Angeletti, F. G., & Turchi, B. (2020). Use of fresh scotta whey as an additive for alfalfa silage. Agronomy, 10(3), 365.

Moselhy, M. A., Borba, J. P., & Borba, A. E. (2015). Improving the nutritive value, in vitro digestibility and aerobic stability of Hedychium gardnerianum silage through application of additives at ensiling time. Animal Feed Science and Technology, 206, 8-18.

NRC (2001). Nutrient requirements of dairy cattle (7th rev. ed.). National Academies Press, Washington, D.C.

Rinne, M., Stefański, T., Franco, M., Jalava, T., & Kuoppala, K. (2024). Forage type and additive effects on fermentation quality and biorefinery performance of silages. Grass and Forage Science, 79, 170–178.

Rohweder, D. A., Barnes, R. F., & Jorgensen, N. (1978). Proposed hay grading standards based on laboratory analyses for evaluating quality. Journal of Animal Science, 47(3), 747-759.

SAS (1998). INC SAS/STAT users' guide (Version 6, 4th ed.). SAS Institute, Cary, NC.

Tatli Seven, T., Seven, I., Iflazoglu Mutlu, S., & Yildirim, E. N. (2021). Silage Additives Usage in Improving Fermentation Quality of Alfalfa Silage: A Review. Animal and Veterinary Sciences, 9(6), 175-180.

Tian, J., Na, R., Yu, Z., Liu, Z., Liu, Z., & Yu, Y. (2018). Inoculant effects on the fermentation quality, chemical composition and saponin content of lucerne silage in a mixture with wheat bran or corn husk. Animal Production Science, 58(12), 2249-2257.

Tremblay, G. F., Morin, C., Bélanger, G., Bertrand, A., Castonguay, Y., Berthiaume, R., &

Allard, G. (2014). Silage fermentation of pm-and am-cut alfalfa wilted in wide and narrow swaths. Crop Science, 54(1), 439-452.

Van Soest, P. J. (1994). Nutritional ecology of the ruminant (2nd ed.). Cornell University Press, Ithaca, NY

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

Wang, Y., Wei, M., Yang, F., Zheng, H., Gao, J., Peng, W., ... & Zheng, Y. (2024). Effects of different additives on the chemical composition, fermentation quality, bacterial community and gene function prediction of caragana korshinskii kom. silage. Agronomy, 14(10).

Yang, F., Wang, Y., Zhao, S., Feng, C., & Fan, X. (2022). Dynamics of the fermentation products, residual non-structural carbohydrates, and bacterial communities of wilted and non-wilted alfalfa silage with and without lactobacillus plantarum inoculation. Frontiers in Microbiology, 12.

Zi, X., Liu, Y., Chen, T., Li, M., Zhou, H., & Tang, J. (2022). Effects of sucrose, glucose and molasses on fermentation quality and bacterial community of stylo silage. Fermentation, 8(5), 191.

Turkish Journal of Range and Forage Science, 2025, 6(1): 18-29
doi: 10.51801/turkjrfs.1569233

Research

Turkish Journal of Range and Forage Science
https://dergipark.org.tr/tr/pub/turkjrfs

Determination of Feed and Silage Values of Some Vegetable Residues Left in the Field

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A R T I C L E I N F O

Received *28/01/2025*
Accepted *05/03/2025*

Keywords:

Some vegetable residues,
silage values,
silage quality,
yield

A B S T R A C T

This study was conducted between 2013 and 2015 in the Çarşamba and Bafra districts of Samsun province to quantify the amount of post-harvest residues (kg da^{-1}), including stems, branches, leaves, and unmarketable fruits, most widely grown plants in the region and considered waste. Additionally, the quality and palatability of silages produced from these residues without additives were evaluated. In the study, tomatoes (T), fresh beans (FB), capia pepper (CP), pointed pepper (PP), white cabbage (WC), and red cabbage (RC) grown in 9 villages in Bafra district and 7 villages in Çarşamba district of Samsun were used. Maize (M) was used as a standard. The research was conducted to according randomized block design with 10 replications. The highest and lowest dry matter values in vegetable residues were obtained from T with 25.73% and WC with 14.68%, respectively. The highest and lowest amounts of residue taken from the unit area were obtained from WC with 2791.9 kg da^{-1} and FB with 988.6 kg da^{-1}, respectively. The highest and lowest values obtained from the silage analyses were as follows: pH (6.22 in T - 4.73 in WC), crude ash (38.95% in WC - 26.16% in FB), organic matter (73.87% in FB - 54.98% in WC), crude protein (15.86% in FB - 13.32% in FB), crude fat (3.17% in FB - 0.7% in CP), ADF (39.98% in PP - 16.96% in RC), and NDF (51.59% in T - 22.64% in RC), respectively. According to Flieg scores, it has been determined that CP is in the "good" quality class, FB, PP, WC, and RC are in the "moderate" value, and T is in the "low" quality class. According to the Relative Feed Values, it was determined that WC and RC were "highest", PP and FB were "very good", T and CP were "good" and all silages were consumed by animals in palatability tests. In the final scoring, the highest score after M was obtained from CP, followed by PP, FB, WC, RC, and the lowest score was obtained from T silage.

1. Introduction

Considering the bottlenecks in meat and milk production throughout our country, it is seen that the main issue is high production costs and the biggest cost factor is feed input. For this reason, it is widely accepted that an increase in competitiveness in domestic and foreign markets is possible by reducing feed costs. Calculations show that approximately 55 million tons of roughage is required annually based on dry matter in Türkiye. Our need for roughage, cannot be met with an average of 17-20 million tons of quality roughage obtained from the existing forage crops and

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pastures (Çelik and Demirbağ, 2013; Özkan, 2020; Yavuz et al., 2020).

Roughage is defined as any material with a water content of more than 14% in its natural state or a crude cellulose content of more than 16% in dry matter and low in digestible organic substances and energy value (Akyıldız, 1983; Kılıç, 2000; Harmanşah, 2018; Oruç and Çolak, 2019).

In our country, apart from meadows, pasture and forage plants, which are among the sources of quality roughage production, there are other roughage sources with low forage value.The common basic characteristics of the roughage sources with low feed value are high crude fiber, lignin, and hemicellulose ratios, low energy content, crude protein, and digestible organic matter levels (Akyıldız, 1983; Jeroch et al., 1993; Gülsün and Miç, 2018; Harmanşah, 2018; Oruç and Çolak, 2019). However, these roughage sources are broken down into organic acids by cellulolytic bacteria living in the rumen of ruminant animals, and these acids are used in animal energy metabolism (Ensminger et al., 1990; Özel and Sarıçiçek, 2009; Tekce and Gül, 2014).

While studies on the improvement of pasture and forage crops continue in Samsun, which has been selected as the project area, it has been determined that abundant residues originating from vegetable agriculture, which constitutes a potential value for the region, have emerged. The residues in question have the potential to be used in silage production, which is a valuable feed source in ruminant (ruminant; cattle, sheep, goat, etc.) breeding.

It is known that there is a significant level of animal existence in Samsun. Although forage cultivation and production have increased 5-6 times in the last 10 years, when evaluated together with pastures, it is seen that roughage production is far from meeting the need.

In 2014, the roughage production of Samsun province, including silage, fodder crops, and pastures, was 350.9 tons on a dry matter basis (Anonymous, 2014). Considering the animal existence of Samsun province, the amount of roughage needed is 878.9 tons based on dry matter (Anonymous, 2014). These figures reveal that there is a high difference of 528.0 tons between production and need. It has been calculated that the residual mass that emerges after the production of only six species in vegetable agriculture in the region can be 456.6 tons and it is thought that some of the roughage needed can be met from here.

With this study, it is aimed to meet some of the insufficient roughage needs in livestock activities in Samsun by evaluating vegetable residues.

2. Material and Methods

The materials of this study were collected from farmer's land in 9 villages in Bafra district of Samsun and 7 villages in Çarşamba district between 2013-2015. The material was commercially produced Tomato (T) (Solanum lycopersicum), Fresh Bean (FB) (Phaseolus vulgaris), Capia Pepper (CP) (Capsicum annuum 6conoides), Pointed Pepper (PP) (Capsicum annuum var. longum), White Cabbage (WC) (Brassica oleracea var. capitata sub. var. alba), Red Cabbage (RC) (Brassica oleracea var. capitata sub. var. rubra) form the residual parts consisting of leaves, branches, stems and worthless fruits. As packaging material 5 kg yellow and 50 kg black plastic bags were used, and coarse table salt (3%) was used as an additive. The values for maize (Zea mays) silage were determined as the averages of the results of previous scientific studies (Also, maize silage was not used).

Residues of vegetable species were taken from parcels with an area of 3 da and above, which were determined to represent all production areas. The study was planned with 10 replications according to the randomized blocks experimental design and the results were analyzed with the Jump statistical program and the obtained data were compared with the LSD multiple comparison test. In the selected districts in Samsun province, 10 fields were determined each representing the province from T, FB, CP, PP, WC, and RC vegetable types. Residues were collected from three distinct sites to accurately represent each parcel, and care was taken to ensure that the parcels chosen as application subjects were at least 3 da. For each replication, in order to represent the selected field homogeneously, three samples were taken from the harvested areas for each species, and then weighed and mixed. To determine the dry matter ratios of the raw materials, 500 g of green parts were taken to represent the mixture. The DM ratios were determined by drying it in an oven at 60 C0 for 72 hours. Yields per unit area were found by dividing the total weight of the harvested material and the harvested area per unit area (da). The material to be silaged was kept for one day after harvest, then cut into 2-5 cm pieces, filled into 5 and 50 kg plastic bags by adding 3% salt, and sealed by vacuuming. For physical and chemical analyses 5 kg bags, and for palatability tests, 50 kg bags were used. Silages were opened after their fermentation was completed in 60 days. For the analysis, the silage samples of 500 g each were dried in a drying oven at 60 °C for 72 hours, and the dry matter ratios were determined. Silages obtained from plant residue materials were used to determine the dry matter (DM), crude protein (CP), crude oil (CO), crude fiber (CF), and crude ash (CA) and the analyses were made according to AOAC (1990). The analyses of acid detergent fiber (ADF) and neutral detergent fiber (NDF) were performed according to Van Soest et al. (1991). The analysis were conducted using the Ankom fiber detector. For the volatile fatty acids (VFA; acetic acid, butyric acid, and lactic acid) determination, the Lepper method was used. Sensory and physical analyses and pH measurements were conducted as reported by Karabulut and Canbolat (2005). The residual material was harvested in 10 fields (parcels) of T, FB, CP, PP, and WC types and 8 fields of RC type. Due to soil cultivation being done without waiting after harvest, RC type material could not be obtained in two plots. In the selection of the plots, the distribution of the species in question throughout the province was taken into account. The waste collection process of the applications was carried out after the commercial harvest of the vegetables. The places where vegetable residues were collected and the number of areas are given in Table 1.

Table 1. Districts and villages where the study was conducted according to the application subjects.

Species	**Location**	**Villages**
T	Bafra	Karpuzlu (2), Doğanca (5), Koşu (2), Agıllar (1)
FB	Çarşamba	Ahubaba (1), Durakbaşı (2), Karamustafalı (3), Ovacık (2)
CP	Bafra	Karıncak (2), Türbe (2), Koşu (3), Doğanca (2), Yeşilyazı (1)
PP	Bafra	Karpuzlu (1), Koşu (2), Türbe(2)
	Çarşamba	Karamustafalı (1), Kumtepe (2), Kurugöl (1), Bölmeçayır(1)
WC	Bafra	Türbe (2), Karıncak (5), Karpuzlu (1), Sarıköy (2)
RC	Bafra	Karıncak (3), Koşu (1), Türbe (2), Sarıköy (1), Doğanca (2), Altunova (1)

Waste collection work was carried out in 15 different parcels in 7 villages in Çarşamba district and 45 different parcels in 9 villages in Bafra district. For T, CB, WC, and RC residual collection was carried out only in Bafra district. FB was only collected from Çarşamba district, whereas PP was collected from both Bafra and Çarşamba districts. An average of 6 calico cows of OMU Faculty of Agriculture in the 3rd and 4th lactations were used for the palatability tests. First of all, an exercise period was applied to the animals to prevent diarrhea. Each silage was fed to 2 animals. In the experiment, 1, 2, 4, 6, 8, 10, and 12 kg of silage were used and a total of 258 kg of residual silage of each species was used. The animals were fed with silage after morning and evening milking. In addition, the animal's feed consumption was observed every two hours. Rejection threshold, low difference threshold, high difference threshold, and preference threshold which are considered preference index values were defined as 20%, 40%, 60%, and 80% (consumption rates of dry matter given at the start), respectively. The green yield of the maize plant and the chemical and technological values of the silage feed was taken as the average of the values obtained from the previous studies carried out in our country (İptaş, 1993; Alçiçek et al., 1999; Filya, 2004; Çiğdem and Uzun, 2006; Karayiğit, 2005; Özdüven et al., 2009; Erdal et al., 2009; Özata et al., 2012; Çakmak et al., 2013; Konca et al., 2005; Kavut and Geren, 2015; Kaplan et al., 2017; Kökten et al., 2017; Kokten, 2020). Comparison data of corn silage is given in Table 2.

Table 2. Basic comparison data of maize silage.

Silage Material	% DM	pH	CP	CA	RFV	Yield (kg da^{-1})	Palatability Score	Sensory test Score	OA Score
Maize	28.38	4.06	7.16	7.28	150<	6139.50	100.00	19	63

The "weighed grading method" was used to score the wet residue yield of the residual materials of the maize plant as the comparison material and the pH, sensory tests, DM, CP, CA, RFV, OA (organic acid), and palatability tests of the silages by putting them into a single table (Serdar, 1994; Demirsoy, 1999; Çelikel, 2005). Scoring was determined separately for each data out of 10 points. Accordingly, the Könisberg method was used in scoring pH and sensory tests. In the scoring of pH assessments scoring was made between 0-4. The obtained scores were processed according to the "score*10/4" formula. In the evaluation of color, smell, taste, and structure of sensory tests, the best and worst values (0-4 / 0-7 / 0-4) were scored. The total score obtained was in the range of 0-20, so it was used in the "10 / 20 * score" formula. processed accordingly. Green residual values were processed according to the formula "yield*10/ highest yield". DM values were evaluated between 0-35%, 2 points between 0-15%, and 2 points were added for each 5% increase. CP values were scored as 0-15% and 16=<, 1 point between 0-8, and then the scoring was increased by 1 in every 1-unit interval and 16+ was accepted as 10 points. CA values were evaluated between 0-40%, 0-10% was accepted as 10 points, and every 5% increase was reduced by 1 point. RFV values were scored as 0-9 points in the range of 40-150 and above 150 as 10 points. OA values were scored between 1-10 points, with a 1-point increase for every 10-point increase in the score range of 0-100. The score for the palatability test values was created according to the "preference index values", and every 10% value between 10-100% was evaluated as a point and scored between 1-10.

3. Results

3.1. Dry Matter Ratio and Wet Residual Yield

Table 3. DM ratios and wet residue yield of the residues that are the subject of the application.

Species	DM (%)	Fresh residual yield (kg da^{-1})
T(Tomatoes**)**	25.72 A	1.083 C
FB(Fresh Beans)	18.84 C	988.6 C
CP(Capia Pepper)	21.94 BC	1.867 B
PP(Pointed Pepper)	23.52 AB	2.515 A
WC(White Cabbage)	14.82 D	2.662 A
RC(Red Cabbage)	20.12 C	2.188 AB
Average	**20.82**	**1.884**
CV (%)	16.50	33.06
Level of Importance	**	**
LSD (0.05)	3.09	5.61

When Table 3 is examined, the highest DM ratio was determined in T residue, followed by PP, CP, and RC, and the highest residual yield was determined from WC, PP, and RC.

Table 4. Green part residue production in the species studied in Samsun in 2014

Working Area	Species	Year	Cultivation Area (da)	Residue Yield (Ton/da)	Total Fresh Residue Production (Ton)
Samsun	**T**	2014	51.034	1.082	55.218
	FB	2014	82.093	0.988	81.107
	CP	2014	27.480	1.867	51.305

	PP	2014	55.344	2.514	139.134
	WC	2014	28.936	2.791	80.760
	RC	2014	22.440	2.188	49.098
Total			**267.327**		**456.622**

When Table 4 is examined, it is seen that the highest residue production in Samsun is obtained from the PP type with 139.1 tons. The least amount of residue is obtained from the RC type with 49.1 tons. A total of 456.6 tons of waste material was produced from six vegetable types (Anonymous, 2014).

3.2. Analysis and Findings Conducted in Silo Feed

3.2.1. pH and Sensory Tests

Table 5. pH, sensory tests, and the Flieg score values in silage of vegetable residues

Species	**pH**	**Flieg Point**	**Score**	**Sensory Test**	**Score**
T (Tomatoes)	6.22	22.0	**Low** (21-40)	13.0	**Moderate** (10-13)
FB(Fresh Beans)	4.93	59.0	**Moderate** (41-60)	13.0	**Moderate** (10-13)
CP(Capia Pepper)	4.88	61.0	**Good** (61-80)	13.5	**Moderate** (10-13)
PP(Pointed Pepper)	5.47	47.0	**Moderate** (41-60)	10.5	**Moderate** (10-13)
WC(White Cabbage)	4.73	52.43	**Moderate** (41-60)	15.84	**Good** (14-17)
RC(Red Cabbage)	5.19	49.75	**Moderate** (41-60)	14.73	**Good** (14-17)

Standard pH ranges are 3.5-5 (Kutlu, 2011). In silage samples, the highest pH value was determined at T and the lowest at WC. The pH values of PP, T, and RC species were above the limit values specified in the literature. In terms of sensory tests, it was determined that WC and RC have "good" values, while T, FB, CP, and PP resulted in "moderate" values. According to the Flieg scores, it was determined that CP was in the "good" quality class, FB, PP, WC, and RC were in the "moderate", and T was in the "low" quality class (Table 5).

3.2.2. Nutrient analysis

Table 6. CP, CA, OM, CO, ADF, and NDF analysis results in silage of vegetable residues

Species	**DM (%)**	**CA (%)**	**OM (%)**	**CP (%)**	**CO (%)**	**ADF (%)**	**NDF (%)**
T	29.34 A	31.40 B	68.59 B	15.03 AB	2.64 AB	38.48 AB	51.58 A
FB	25.70 B	26.15 C	73.87 A	15.85 A	3.16 A	34.60 B	46.48 A
CP	25.68 B	27.91BC	72.08AB	14.51 ABC	0.76 E	38.70 AB	48.29 A
PP	28.01 A	27.03 C	72.96 A	14.05 BC	1.72 CD	39.97 A	49.64 A

WC	18.31 D	35.95 A	57.68 C	13.32 C	2.15 BC	18.12 C	24.17 B
RC	20.63 C	38.49 A	54.97 C	13.34 C	1.38 DE	16.95 C	22.63 B
Average	**24.61**	**31.15**	**66.69**	**14.3**	**2.21**	**31.142**	**40.47**
CV (%)	10.17	13.29	5.8	**13.02**	36,9	15.6	14.05
Level of Importance	**	**	**	*	**	**	**
LSD (0.05)	2.24	3.73	3.53	1.68	0.65	4.39	5.12

In DM, CA, CO, OM, ADF and NDF analyzes, the difference between species was found to be statistically very significant, in CP analyzes the difference between species was statistically significant. DM contents in silages T and PP are in the same group in residual silages. The lowest DM rates were obtained from WC and RC. When the CA assets were examined, it was determined that WC and RC had the highest CA presence and were in the same group. T and RC were in the second group, and the lowest CA presence was in FB and PP. When OM values are examined in terms of their direction, the highest to lowest OM values were found in FB, PP, CP, T, WC, and RC, respectively. When the CP ratios are examined, the highest value was obtained from FB, followed by T, and PP, while the lowest was found in silages obtained from WC, and RC. As for their CO yields, the highest CO value was obtained from FB, followed by T, WC, PP, RC and CP, respectively. In terms of ADF ratios, the highest ADF ratio was determined in PP, CP and T, followed by FB. The lowest ADF was determined in WC and RC. While the highest NDF ratio was T, FB, CP, PP, the lowest NDF value was determined in RC and WC (Table 6). RFV values in silage of vegetable residues are given in Table 7.

Table 7. Relative feed values in silages of vegetable residues subject to application

Species	RFV	Score
T(Tomatoes**)**	116.74	Good (124-103)
FB(Fresh Beans)	134.55	Very good (151-125)
CP(Capia Pepper)	122.82	Good (124-103)
PP(Pointed Pepper)	125.98	Very good (151-125)
WC(White Cabbage)	291.38	Very good (>150)
RC(Red Cabbage)	317.26	Very good (>150)

Relative Feed Value was found to be “good” and “very good” in all vegetable species subject to the application. Relative feed values were very high in WC and RC species.

3.2.3. Organic Acid analyzes

Table 8. AA, BA, and LA values in the silage of the vegetable residues that are the subject of the application

Species	% LA*	% AA*	% BA*	Fleig Points	Score
T	0.96	2.24	-0.78	50.5	III = Satisfactory
FB	1.47	2.12	-0.28	39.7	IV = Moderate
CP	0.65	0.43	-0.04	65.8	II = Good
PP	1.00	0.68	-0.08	68.6	II = Good
WC	1.67	4.10	-2.61	55.5	III= Satisfactory
RC	1.45	0.35	-0.02	88.2	I = Very good

*LA (Lactic acid), AA (Acetic acid), BA (Butyric acid)

The most ideal limit values for LA are ≥ 2%, AA < 0.8%, BA = 0 (Kılıç, 2006; Kılıç, 1986; Alçiçek and Özkan 1996). While RC was "very good", CP and PP were "good", T and WC were "satisfactory", FB was "moderate" in the vegetable species subject to the application (Table 8).

3.2.4. Palatability Tests

Table 9. The results of palatability tests in silage of vegetable residues

Species	Consumption (%)	Feed amount (kg day)						
		1	2	4	6	8	10	12
T	Consumed	80	80	100	100	100	100	100
	Remaining	20	20	x	x	x	x	x
FB	Consumed	100	100	100	100	100	100	100
	Remaining	x	x	x	x	x	x	x
CP	Consumed	100	100	100	100	100	100	100
	Remaining	x	x	x	x	x	x	x
PP	Consumed	100	100	100	100	100	100	100
	Remaining	x	x	x	x	x	x	x
WC	Consumed	100	100	100	100	100	100	100
	Remaining	x	x	x	x	x	x	x
RC	Consumed	100	100	100	100	100	100	100
	Remaining	x	x	x	x	x	x	x

Initially, some reluctance was observed in the consumption of T silage at 1 and 2 kg day applications. In all other applications, all the silages given were consumed by the animals (Table 9).

Table 10. Combined final scoring table of some physical and chemical properties of the silages of the studied species and the comparative material

Species	Residual yield (0-10)	pH (0-10)	Sensory Test (0-10)	DM (0-10)	CP(0-10)	CA (0-10)	RFV (0-10)	OA (0-10)	Palatability test (0-10)	Total (points)
T	1.51	0	6.5	8	9	5	7	6	9	**52.01**
FB	1.38	2.5	6.5	8	9	6	8	4	10	**55.38**
CP	2.6	2.5	6.75	8	8	6	7	8	10	**58.85**
PP	3.5	0	5.25	8	8	6	8	8	10	**56.75**
WC	3.9	2.5	7.92	4	7	4	10	6	10	**55.32**
RC	3.05	0	7.36	6	7	4	10	9	10	**53.36**
M	10	7.5	9.5	8	1	10	9	9	10	**74**

When the values of residual silages from all evaluation criteria are scored in a single table, the comparison material maize (M) has the highest value with 74 points, followed by CP, PP, FB, RC, and WC, respectively. Type T had the lowest value with 52.01 points (Table 10).

4. Discussion

The DM ratios of the residues of the studied species ranged from 18.68% (WC) to 25.73% (T). Considering that the DM ratio of the maize plant is 34.75%. The DM rates of the species in the study were lower when compared to maize. The DM ratio required to make silage feed in water-rich materials should be between 25-35% (Kutlu, 2011 For the vegetable species that are the subject of the application in the study, only residue obtained from T falls within this range. In a study conducted by Ozkul et al. (2011), where some values of different vegetable residue mixtures, wheat straw and wheat bran were evaluated, the DM contents of vegetable mixtures were found to be 12.16%. DM content of silage prepared from Chinese cabbage residues was reported as 13.5% in a research by Kafle et al. (2014). In silage studies to be carried out with the materials under study, to increase the DM ratio of the materials, it can be considered that withering, mixing with other materials with high DM ratio at certain rates, or making silages after removing the high percentage of water in their structure by mechanical methods.

In terms of yield per unit area, there is a high difference between the comparison material M plant and materials used in this study. The closest yield value to M (6139 kg da^{-1}) was obtained from PP, RC, and WC species. In the previous literature, there are very few studies on the determination of yield values per unit area in the species that are the subject of the application. In the study, the residues left over from tomato cultivation in open areas were found to be 1082 tons da^{-1}. Di Blasi et al. (1997), "The yield per unit area of tomato residues in greenhouses is 1.3 tons da^{-1}", Kürklü et al. (2004) reported that only 111.481 tons of dry matter from tomato greenhouses and 15.8 tons from eggplant greenhouses are produced in the Antalya region, where intensive greenhouse cultivation is carried out. The reasons for the difference may be due to regional, aquaculture, species, decare, and total yield differences.

Acceptable pH values in silo materials vary between 3.5-4.9 (Kutlu, 2010). The average pH value of M silages was found to be 4.06. As for the materials used in this study, it was determined that WC, CP, and FB, have pH values within the acceptable range together with M. Whereas T, PP, and RC have pH values above the acceptable range values.

Ozkul et al. (2011) found that pH values in 7 different silages made from vegetable residues were between 4.09 and 4.20. In a study conducted by İptaş (1993), pH values were found to be between 4.25-4.6 in 3 different corn varieties, 6.15 in bean residue and 5.3 in cowpea. Kafle et al. (2014) reported a pH value of 5.8 in silage prepared from Chinese cabbage residues. When the pH values in all three literatures above are examined, it can be seen that the pH data obtained from subjects other than M are in parallel with the data from our study.

In the study, the CP value was determined to be between 13.32-15.86%. Whereas the CP value in the comparison material M is 7.16%. In roughage, CP is a very important criterion. All of the materials used in this study nearly have a CP ratio of 2 times more than the benchmark material. It is thought that the reason for the high pH value of the silages obtained from the examined species is due to their high CP content and low water-soluble carbohydrate content. Ishida et al. (2000) reported that easily soluble carbohydrates should be added for better fermentation and silage quality due to the high protein content in silages made with sweet potato leaves.

Color, odor, and structure were examined in the evaluation made in terms of physical properties, and it was seen that WC and RC were "good" and other applications were "moderate". Although there are acceptable data, it is thought that this result may be due to the low DM content of the residues collected from the field, especially the worthless fruits, and possible decay.

While the DM ratios of T and PP species in silages of vegetable species were statistically in the same group, FB and CP were in a subgroup. The lowest DM rate was determined in WC and RC species. The DM ratio obtained from silages obtained from maize plant is 28.38% and the ratio is the same as T. While the DM rate of M silage is expected to be higher, it is thought that it is due to silage being made earlier than necessary uncontrolled farmer conditions. It is thought that the main reason for the low DM rate of the residues in the study is due to the high water content during harvest. Vilela de Rezende et al. (2015) found DM between 20-25% in their study investigating the silage possibilities of milled maize added cabbage residues. No DM value can be compared with the DM value obtained in our study since cabbage residues were not siled up alone in the study in question. However, the fact that the DM content is so low even in the ground maize added silage reveals that the DM values determined for WC and RC in the current study (18.31% and 20.63%, respectively) are at an acceptable level. It is thought that increasing the DM ratio of silage materials will make the study more successful. Increasing the DM ratio of silage materials will make the study more successful. Obtaining a high DM ratio can be achieved by withering, mixing with materials with high DM ratios, making silage, or processing the high water content in the materials by crushing or squeezing. However, considering that the harvest dates of these materials are between September and February, and considering the abundance of autumn rains in the region, there may be limitations in withering. Opportunities to make silage by mixing with materials with high DM content or by breaking them in one go by methods that can be developed during harvesting from the field, and then by squeezing or centrifugal effect. It is thought that the possibility of increasing the DM ratio by removing the water should be investigated.

In the evaluation of CA rates, it can be seen that the CA value varies between 26-38% in all application subjects. Considering that the CA value of M is 7.28%, the CA values of the application materials are very high. Ozturk et al. (1998) investigated the possibilities of using amaranth (Amarantus cruentus) as silage feed and determined the CA ratio in silages of amaranth plants grown at 5 different nitrogen doses between 16.7-18.9%. It is thought that the main reason for the high CA ratio in our study may be due to the 3% salt added over the weight of the residues during silage production and the soil material with a high probability of contaminating the residual materials, especially for T, WC, and RC types.

When ADF and NDF values were examined, it was determined that ADF was between 34.61-39.98% and NDF was between 46.48% and 51.59% in T, FB, CP, and PP. In RC and WC, it is seen that ADF values are very low, between 16.96-18.13%, and NDF between 22.64-24.17%. In their study, Özkul et al. (2011) determined that OM 82.72%, CP 22.59%, ADF 26.49%, and NDF 28.69% in silages obtained from 100% vegetable mixture residues. Binversie and Miller. (2013), in the study evaluated comparatively the nutritional contents of maize silage and cabbage silage, where they determined that DM in cabbage was 7%, CP 16.6%, ADF 15.8%, NDF 29%, DM 35%, CP 8.5%, ADF 24%, NDF 43%. Agneessens et al. (2014), in their study, determined the quality values of vegetable and orchard residues compost and silage, vegetable residues silage, and fresh vegetable residues, they found DM of the silage obtained in the section related to vegetable residues to be between 16.1-19.2%. When the data in these studies are compared with the data obtained from our study, the ADF and NDF values of the materials with low DM ratio decreased accordingly, and therefore the low ADF and NDF values of WC and RC can be explained in this way.

ADF and NDF values were also determined as low due to the medium and low DM % ratios in silo feeds. As a result, RFV was found to be good and very good in all application subjects. ADF and NDF values, which are very low, especially in cabbage species, have maximized the RFV value of these materials.

The LA values in the residual silages of the species are low when compared with the literature data. Accordingly, the amounts of AA and BA increased. As a result of scoring the current findings, fleig scores in all species revealed values between moderate and good. If the cabbage residues are ensiled without additives, the lactic acid level decreases and it is not possible to obtain quality silage (Cao et al., 2011).

Compared to other bacteria, lactic acid bacteria can develop best in an oxygen-free environment (15-25 C°), at a pH of 4-5, in 35-40% dry matter, and if the silo feed contains 2-3% sugar (Alçiçek et al.1999. The required LA level in silage feeds is 2% (Kılıç, 2006). The low LA values can be explained by the high CP values of the species and the low carbohydrate content.

5. Conclusion

When the time of consuming the silage of the animals was followed, it was observed that they consumed the CP and PP silages more eagerly. Between April 1st and October 1st, when green fodder is abundant in nature, the roughage needs of animals are provided by nature or from the roughage stock of the enterprise. Grain silages and maize silages, which are more preferred by animals, are mostly consumed in the early winter and early spring periods. Considering the daily caloric needs of the animals, it is thought that it would be more appropriate to feed the silages that are the subject of the study in the winter period and can be consumed more lovingly in this period. As a result of the evaluation of the study materials as silage in Samsun, it is thought that a significant part of the roughage that the province will need can be obtained from here. There has been no problem in the consumption of silo feeds obtained from waste materials by animals. Although there is little reluctance in T type silages, it has been observed that they consume all other types with pleasure. It has been determined that the best quality and preferable silage feed is KB when compared to the M material in terms of silo feed quality, and then PP, FB, WC, RC, and T can be preferred, respectively. Mechanization practices that will ensure the removal of high water content by crushing and squeezing the waste materials during harvest and centrifugal effect when necessary. It is thought that it may be appropriate to mix the vegetable species under study with different silage materials which are rich in carbohydrates. This will increase the DM ratio, in certain proportions. For these materials, which have production potential and substantial feed values, to be used as silage feed, it is beneficial to improve their quality values and to develop mechanization methods and practices that will facilitate harvesting and silage production.

Acknowledgement

This study is derived from the results of the research project TAGEM /TBAD/14/A03/P02/002. I thank MSc Cemil UÇAR, MSc Fatih KUMBASAR and MSc Berrak MEMİŞ for their contributions to the article.

References

Agneessens, L., De Waele, J., & De Neve, S. (2014). Review of alternative management options of vegetable crop residues to reduce nitrate leaching in intensive vegetable rotations. Agronomy, 4(4), 529–555. https://doi.org/10.3390/agronomy4040529

Akyıldız, R. (1983). Feeds Information and Technology. Ankara University Faculty of Agriculture Publication No: 868, Ankara.

Alçiçek, A., Kılıç, A., Ayhan V., & Özdoğan, M. (2010). Forage production and problems in Turkey. Turkey Agricultural Engineering VII. Technical Congress, 11(15), 1-10.

Alçiçek, A., Tarhan, F., Özkan, K., & Adışen F. (1999). A Study on the Determination of Nutrient Content and Silage Quality of Silo Feed Made in Some Dairy Farms in İzmir Province and its Surroundings Animal Production 39-40: 54-63.

Alçiçek, A., & Özkan, K. (1996). Determination of lactic acid, acetic acid, butyric acid in silo feeds by distillation method. Journal of Ege University Faculty of Agriculture 33(2-3), 191-198.

Anonymous. (2014). Crop Production Statistics Database, forage crop production and silage corn production data in Samsun. According to ISIC Rev3 Classification.

AOAC. (1990). Official Methods of Analysis. 15th ed., Association of Official Analytical Chemists. Arlington, VA. Ashbell, G., Z. G. Weinberg, A. Azrieli, Y. Hen and B. Horev,.1991. A Simple System to Study the Aerobic Deterioration of Silages. Canadian Agric. Eng. 33,391-393.

Binversie, L., & Miller, Z. (2013). Feeding Cabbage Waste. University of Wisconsin Extension, Madison, WI, USA.

Cao, Y., Cai, Y., Takahashi, T., Yoshida, N., Tohno, M., Uegaki, R., Nonaka, K., & Terada, F. (2011). Effect of lactic acid bacteria inoculant and beet pulp addition on fermentation characteristics and in vitro ruminal digestion of vegetable silage. Journal of Dairy Science, 94, 3902-3912.

Çakmak, B., Yalçın, H., & Bilgen, H. (2013). The Effects of Packing Pressure and Storage Time on Raw Nutrient Content and Quality of Harvested and Fermented Corn Silage, Ege University, Faculty of Agriculture, Department of Agricultural Machinery, İzmir, Turkey Journal of Agricultural Sciences 19, 22-32.

Çelik, A., & Demirbag, N. (2013). The effect of agricultural supports on forage crops cultivation and production in Turkey. Publication No: 215 ISBN: 978-605-4672-40-0. Ankara

Çelikel, G. (2005). Selection of Big Nut (*Arbutus unedo* L.Eracaceae) in the province of Sinop and the town of Yakakent of Samsun. OMU Department of Horticulture, Master's thesis. Samsun.

Çiğdem, İ., & Uzun, F. (2006). A Research on Some Silage Sorghum and Corn Varieties That Can Be Cultivated As Second Crop In The Soil Areas Of Samsun Province. Omu Zir. fac. Journal, 21(1), 14-19.

Demirsoy, H. (1999). Studies on the breeding of Can plum types in Çarşamba plain and the determination of the usability of some selected types as clone rootstocks for Peach and Plum. OMÜ Horticulture Department, Ph.D. thesis. Samsun.

Di Blasi, C., Tanzi, V., & Lanzetta, M. (1997). A Study of the Production of Agricultural Residues in Italy. Biomass and Bioenergy, Vol. 12 No.5 pp. 321–331.

Erdal, Ş., Pamukçu, M., Ekiz, H., Soysal, M., Savur, O., & Toros, A. (2009). Determination of Silage Yield and Quality Characteristics of Some Silage Corn Variety Candidates Akdeniz University Journal of Faculty of Agriculture, 22 (1), 75–81.

Filya, I. (2004). Studies on the Use of Organic Acids in Silage Fermentation 1. The effect of a formic acid-based preservative on the fermentation, microbial flora, aerobic stability and in situ degradability properties of corn silages made under laboratory conditions. Journal of Agricultural Sciences, 11 (1), 51-56.

Gülsün, B., & Miç P. (2018). A Multi-Purpose Programming Approach for Economical Determination of Basic Feed Amounts in Ration Preparation. Niğde Ömer Halisdemir University Journal of Engineering Sciences, 7(2), 634-648.

Harmanşah, F. (2018). Quality roughage production problems and suggestions in Turkey. Turktob Magazine, 25, 9-13.

Ishida, H., Suzuno, H., Sugiyama, N., Innami, S., Tadokoro, T., & Meakawa, A. (2000). Nutritive value on chemical components of leaves stalks and stems of sweet potatoes (*Ipomoea batata* poir.). FoodChem., 68, 359-367.

İptaş, S. (1993). A research on the feed values of different corn varieties and legumes ensiled as plain and mixed. Gaziosmanpaşa University Faculty of Agriculture Journal, 10(1993), 202-209.

Jeroch, H., Flachowsky, G., & Weissbach, F. (1993). Futtermittelkunde. Gustav Fischer Verlag, Stuttgart.

Kafle, G. K., Bhattarai, S., Kim, S. H., & Chen, L. (2014). Anaerobic digestion of Chinese cabbage waste silage with swine manure for biogas production: batch and continuous study. Environmental Technology, 35, 2708-2717.

Kaplan, M., Kokten, K., & Akcura, M. (2017). Assessment of Genotype × Trait × Environment interactions of silage maize genotypes through GGE Biplot. Chilean Journal of Agricultural Research, 77(3), 212-217.

Karabulut, A., & Canbolat, Ö. (2005). Feed Evaluation and Analysis Methods. U.U. Publications, Pub. No: 2.05.048.0424, Bursa.

Karayiğit, İ. (2005). Research on Silage Quality of Some Hybrid Maize (*Zea mays* L.) Varieties at Different Maturity Periods Master Thesis Kahramanmaraş September 2005.

Kavut, Y.T., & Geren H. (2015). The Effects of Different Pre-plant and Sowing Time Applications on Yield and Some Quality Traits of Silage Corn (*Zea mays* L.). Turkish Journal of Agriculture and Natural Sciences, 2(2), 163–170.

Kılıç, A. (2000). Roughage production and its problems. V. Technical Congress of Agricultural Engineering of Turkey, Volume 1, 17-21 January, Ankara, p. 845-858.

Kılıç, A. (1986). Silo Feed: Teaching, Learning and Practice Recommendations. Bilgehan Press, Izmir.

Kılıç, A. (2006). Determination of Quality in Forages. Harvest Publishing, Istanbul.

Kokten, K. (2020). GGE-Biplot analysis for genotype-environment interactions in some quality traits of silage maize genotypes. The Journal of Animal & Plant Sciences, 30(2), 410-419.

Konca, Y., Alçiçek, A., & Yaylak, E. (2005). Determination of Silage Quality in Silo Feed Made in Dairy Farms. Animal Production, 46(2), 6-13, 2005, İzmir.

Kökten, K., Kaplan, M., & Akçura, M. (2017). Evaluation of relation between dry matter yield and some quality properties of silage corn varieties grown in different circles by variety property Biplot analysis. KSU J. Nat. Sci., 20, 46-51.

Kutlu, H. (2011). Silage Production and Feeding with All Aspects. Çukurova University Faculty of Agriculture Department of Animal Science. Adana.

Kürklü, A., Bilgin, S., Külcü, R., & Yaldız, O. (2004). A Study on determination of amount and energy contents of some vegetable biomass wastes. In Bioenergy Symp (pp. 69-75).

Oruç, K. O., & Çolak, M. (2019). Feed Selection by Fuzzy Analytical Hierarchy Process Method. Süleyman Demirel University Visionary Journal, 10(25), 495-510.

Özata, E., Öz, A., & Kapar, H. (2012). Determination of Yield and Quality Traits of Silage Hybrid Corn Variety Candidates. Journal of Agricultural Sciences Research, 5 (1), 37-41, SSN: 1308-3945, E-ISSN: 1308-027X, TABAD.

Özdüven, M.L., Koç, F., Polat, C., Coşkuntuna, L., Başkavak, S., & Şamlı H. E. (2009). The Effects of Vegetation Period on Ensiling Fermentation Properties and Feed Value in Some Corn Varieties. Tekirdağ Faculty of Agriculture Journal, 6(2), Tekirdağ.

Özel, O., & Sarıçiçek, B. (2009). Presence And İmportance of Rumen Microorganisms İn Ruminants. Tubav Journal of Science, 2(3), 277-285.

Özkan, U. (2020). Comparative Overview and Evaluation of Forage Crops Agriculture in Turkey. Turkish Journal of Agricultural Engineering Research, 1(1), 29-43.

Özkul, H., Kılıç, A., & Polat, M. (2011). Evaluation of Mixtures of Certain Market Wastes as Silage. Asian-Aust. J. Anim. Sci., 24(9), 1243 – 1248.

Öztürk, E., Garipoğlu, A.V., Yıldırım, A., Genç, N., & Acar, Z. (1998). Possibilities of Using Rooster Comb (*Amaranthus cruentus*) as Silo Feed. Journal of OMU Faculty of Agriculture, 13(3), 51-60.

Serdar, Ü. (1994). Breeding of chestnut (*Castanea sativa* Mill.) by selection in Erfelek district of Sinop. OMU, Department of Horticulture, Master's thesis, Samsun.

Tekce, E., & Gül, M. (2014). The importance of NDF and ADF in ruminant feeding. Atatürk University Journal of Veterinary Sciences, 9(1), 63-73.

Van Soest, P. J., Robertson, J. B., & Levis, B. A. (1991). Method for Dietary Fiber, Neutral Detergent Fiber, and Nonstarch Polysaccharides in Relation to Animal Nutrition. J. Dairy Sci., 74, 3583-3597.

Vilela de Rezende, A., Henrique Silveria Rabelo, C., Machado da Silva, M.R., Harter, C.J., & Veiga, R.M. (2015). Wasted cabbage (*Brassica oleracea*) silages treated with different levels of ground corn and silage inoculant. Revista Brasileira de Zootecnia, 44(8), 296-302.

Yavuz, T., Kır, H., & Gül, V. (2020). Evaluation of roughage production potential in Turkey: The Case of Kırşehir Province. Turkish Journal of Agricultural Research, 7(3), 345-352.

Yılmaz, H.Ş., Kökten, K., Kaplan, M., & Uçar, R. (2016). The use of pumpkin seed (*Cucurbita pepo* L.) remains in animal nutrition. Turkish Journal of Agricultural and Natural Sciences, 3(1), 79-82.

Turkish Journal of Range and Forage Science, 2025, 6(1): 30-38
doi: 10.51801/turkjrfs.1697725

Review

Turkish Journal of Range and Forage Science
https://dergipark.org.tr/tr/pub/turkjrfs

Animal Evaluation Possibilities of Aronia (*Aronia melanocarpa* (Michx.) Elliot)

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A R T I C L E I N F O

Received *12/05/2025*
Accepted *28/06/2025*

Keywords:
Animal nutrition,
Aronia,
antioxidant

A B S T R A C T

The aronia plant, which is native to North America, has recently come to the forefront as a berry-like fruit that has attracted interest in terms of its usability in animal nutrition owing to its powerful antioxidant compounds such as anthocyanins, flavonoids, polyphenols and proanthocyanidins. However, studies conducted in our country and around the world have shown that aronia is more suitable for use as a feed additive in animal rations to increase the quality of animal products such as meat, milk and eggs rather than for direct use in animal nutrition. This is particularly evident when compared to quality forage sources such as alfalfa and sainfoin.

1. Introduction

According to the latest research in our country, the number of large cattle increased by 2.5% compared to the previous year, reaching 16 million 208 thousand (excluding buffalo), the number of sheep increased by 4.8% compared to the previous year, reaching 44 million 80 thousand 584 head, and the number of goats increased by 5.0% compared to the previous year, reaching 10 million 822 thousand 84 head (TÜİK 2024), Therefore, exploring new forage sources becomes essential, among which aronia emerges as a candidate. However, since this need cannot be met by the basic roughage sources of our country, which are meadows and pastures, legume-cereal forage crops, and the stems and straws of cereals, importance has been emphasizedto alternative roughage sources in order to increase both production and quality. For this purpose, in addition to legume and gramineous forage plants such as beet (*Beta vulgaris* L.), turnip (*Brassica rapa* L.), pomace, amaranth (*Amaranthus* sp.) and black chard (*Atriplex* sp.) (Tan and Temel 2012), some agricultural industrial by-products (beer pulp, grape pomace, anise pulp) have the opportunity to be evaluated as alternative feed sources (Özdüven et al., 2005). The idea of whether the aronia plant, which has become commercially widespread since 2017 and contains many bioactive compounds including anthocyanins, carotenoids, fatty acids, flavonoids, phenolic compounds and vitamins, will be evaluated in terms of animal husbandry has been on the agenda (Yılmaz et al., 2021).

Aronia fruit has become a well-known food in the field of health and nutrition in recent years. In particular, the bioactive components and nutritional value found in its fruit provide significant health benefits (Gümüştepe et al., 2022). In particular, the secondary compounds present in the fruit have a protective effect and can reduce the risk of people being exposed to diseases (Bayram and Öztürkcan, 2022). A plant belonging to the *Rosaceae* family, Aronia is the fruit of Aronia melanocarpa and has three species: *Aronia*

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arbutifolia (Ell.) Pers. (Red chokeberry), *Aronia melanocarpa* (Black chokeberry) and *Aronia prunifolia* (Marsh.) (Purple chokeberry) (Slimestad et al., 2005; Strigl et al., 1995). This plant, whose natural habitat is North America, is generally known as the Aronia Bush or Black Rosehip. In 1910, Russian scientist Ivan Mitschurin aimed to develop a sweet fruit by hybridizing Sorbus and Mespilus aronia species and for this purpose produced two new varieties called Likernaja and Desertnaja Michurina. After World War II, aronia cultivation spread rapidly in Europe and Russia as of 1946, and large-scale aronia gardens were established especially in the former Soviet Union republics such as Belarus, Moldova, the Siberian Federal District of Russia and Ukraine, and this process continued steadily. Following this, after 1950, it was widely produced in gardens, especially in Eastern Europe, especially in the east, and in European countries in general, especially in Germany (Šnebergrova et al., 2014).

2. Cultivation Areas in the World and Türkiye

In Russia, in 1910, Ivan Mitschurin, who hybridized Sorbus and Mespilus with North American aronia, started breeding studies on aronia and developed two cultivars, called Likernaja and Desertnaja Michurina (Walther and Müller, 2012). Aronia cultivation later became widespread in Europe and Russia from 1946 onwards and was first brought to Japan from the former Soviet Union in 1976. In the 1980s, aronia cultivation began to be active in the countries of the former Soviet Bloc (Czechoslovakia, Bulgaria, Poland, East Germany and Slovenia) and the Scandinavian countries (Denmark and Finland) (Walther and Müller, 2012; Kokotkiewicz et al., 2010). In 1996, Jan Mills Wayne brought important varieties for commercial aronia cultivation from Polish agricultural schools to the United States, and Poland began to supply approximately 90% of the world's aronia production. The planting areas and production values of the countries, including Poland, are given in Table 1, while the varieties commonly used by the countries are shown in Table 2 (Poyraz and Engin, 2019; Fidancı, 2015; Šnebergrová et al., 2014; Strigl et al., 1995).

Table 1. Aronia production values in the world

Countries	Production Areas (ha)	Production Quantities (tons)
Poland	6000	50000
USA	800	2500
Germany	853	1434
Türkiye	78	130
Finland	60	4

Table 2. Aronia varieties cultivated by country

Country	Cultivated Varieties
Denmark	Aron
Czech Republic	Nero
Finland	Viking
Sweden	Hugin
Hungary	Fertödi
Türkiye	Nero, Viking

In Türkiye, it stands out as a smaller producer with a production of 130 tons in an area of 78 hectares. According to 2021 data, aronia cultivation in Türkiye is most intensively carried out in the provinces of Kırklareli (40000 seedlings, 240 decares), Bursa (23500 seedlings, 141 decares) and Manisa (15500 seedlings, 90 decares), while production is more limited in other provinces (Table 3).

Table 3. Number of saplings and production areas in the provinces where Aronia cultivation is economically carried out in Türkiye.

Province	Number of Seedlings (Pieces)	Production Area (da)
Kırklareli	40.000	240
Bursa	23.500	141
Manisa	15.500	90
Kırşehir	8.000	48
Yalova	8.000	48
Çanakkale	7.000	42
Samsun	6.000	36
İzmir	5.000	30
Antalya	3.000	18
İstanbul	3.000	18
Ordu	3.000	18
Ankara	2.000	12

3. Systematics and Morphology

When examined from a botanical perspective, Aronia is defined as Aronia from the Angiosperms (Angiosperms) Division, Eudicolydon (Dicotyledons) Subdivision, Meloideae Class, Rosales Order, Rosaceae (*Rosaceae*) Family, Amygdaloideae Subfamily structure, Maleae Genus. Aronias are frequently confused with chokecherries, which is the common name of Prunus virginiana. Aronia berries and chokecherries both contain polyphenolic compounds such as anthocyanins, but these two plants are somewhat distantly related in the *Amygdaloideae* subfamily. Black chokeberry is a common shrub grown in Central Europe, where it is mostly used for food production (Ekiert et al., 2021).

Figure 1. General view of the aronia plant (https://www.berkefidancilik.com/50-adet-katya-kirmizi-aronya-aronia-fidesi--10-15-cm---brkfdnclk00605; https://www.sopeyzaj.com/aronia-melanocarpa/#prettyPhoto).

The genus Aronia is thought to have three species (Kulling and Rawel 2008; Ekiert et al., 2021). The most common and widely used is *Aronia melanocarpa* (black chokeberry), which originates from eastern North America. The lesser-known *Aronia arbutifolia* (red chokeberry) and the hybrid form of the above-mentioned species, *Aronia prunifolia* (purple chokeberry), were first cultivated in central and eastern North America (Ekiert et al., 2021).

Aronia is a perennial shrubby plant that can grow to 2-2.5 m in height, and the fruit diameter varies between 6-13 mm, while the fruit weight varies between 0.5-2 g. When the fruits are fully ripe, they can be consumed fresh (King and

Bolling, 2020). The aronia plant, which has hermaphroditic flowers, has 5 sepals, 5 petals and 10-30 stamens. The number of flowers in the cluster varies between 20 and 25. Aronia fruits ripen in 90-110 days, depending on the variety, pruning method and climate factors, and are harvested in late August or early September. While the fruit size varies between 1.2-1.7 cm, the water-soluble dry matter ratio is measured between 14-20 Brix and the acidity value is between 0.75-1.05 g citric acid/100 g (Ara, 2002; Kulling and Rawel, 2008; Ochmian et al., 2012; Anonymous, 2021; Ministry of Agriculture and Forestry 2022). Aronia plant produces 8-12 fruits in each bunch starting from the second year of planting, achieves the highest yield in the third year, and 500-1200 kg yield is achieved per decare in five years.

4. Nutritional and Chemical Content

It is known that the fruits in the berry group have rich antioxidant and anthocyanin amounts. Aronia is also included in the berry group and stands out as a plant with various phytochemicals and high antioxidant and anthocyanin capacity. Thanks to this rich variety of phytochemicals, it attracts the attention of researchers and is expressed as a functional product on which studies are concentrated (Yurtkulu, 2022, Eskimez and Polat, 2023). Its fruit is known for its high antioxidant content, rich in vitamin C, fiber and many other vitamins and minerals (Table 4, 5). Particularly, its richness in antioxidants is considered a key factor supporting its health benefits.

Table 4. Nutritional Content of Aronia Fruit

Contents	Value	Reference
Dry Matter (%)	16,7-28,8	Lehmann 1990
Glucose+Fructose (g/kg)	130–176	Lehmann 1990
Oil (%)	0,14	Tanaka and Tanaka 2001
Protein (%)	0,7	Tanaka and Tanaka 2001
Vitamin C (mg/kg)	13-270	Lehmann 1990
Vitamin B1 (μg/kg)	180	Tanaka and Tanaka 2001
Vitamin B2 (μg/kg)	200	Tanaka and Tanaka 2001
Vitamin B6 (μg/kg)	280	Tanaka and Tanaka 2001
Vitamin K (μg/kg)	242	Tanaka and Tanaka 2001
Folate (μg/kg)	200	Stralsjo et al. 2003
l-Malic Acid (g/kg)	13,1	Tanaka and Tanaka 2001
Citric acid (g/kg)	2,1	Tanaka and Tanaka 2001
-β-Carotene (mg/kg)	16,7	Razungles et al. 1989
β-Cryptoxanthin (mg/kg)	12,2	Razungles et al. 1989

Table 5. Chemical Content of Aronia Fruit

Components		Value	Reference
Minerals	Na	26	Tanaka and Tanaka 2001
	K	2180	Tanaka and Tanaka 2001
	Ca	322	Tanaka and Tanaka 2001
	Mg	162	Tanaka and Tanaka 2001
	Fe	9,3	Tanaka and Tanaka 2001
	Zn	1,47	Tanaka and Tanaka 2001
Anthocyanins	Cyanidin-3-arabinoside	14,6- 39,9-58,2	Slimestad et al. 2005; Wu et al. 2004, Oszmianski and Wojdylo 2005
	Cyanidin-3-galactoside	23,7 -99-128,2	Zheng and Wang 2003; Wu et al. 2004, Oszmianski and Wojdylo 2005
	Cyanidin-3-glucoside	1-3,76- 4,2	Slimestad et al. 2005; Wu et al. 2004, Oszmianski and Wojdylo 2005
	Cyanidin-3-xyloside	1-4,7-5,3	Slimestad et al. 2005; Zheng and Wang 2003; Oszmianski and Wojdylo 2005

	Pelargonidin-3-arabinoside	0,23	Wu et al. 2004
Flavonols	Quercetin-3-galactoside	3,7	Oszmianski and Wojdylo 2005
	Quercetin -3-glucoside	2,73	Zheng and Wang 2003
	Quercetin -3-rutinoside	1,5	Oszmianski and Wojdylo 2005
	(–)-Epicatechin	2,7	Oszmianski and Wojdylo 2005
	Chlorogenic acid	30,2	Oszmianski and Wojdylo 2005
	Neochlorogenic acid	29,1	Oszmianski and Wojdylo 2005

5. Ecological Features

Aronia, which can be grown in many parts of the world, has a wide adaptability and the regions where it develops best are temperate areas (Yurtkulu, 2022). Adapted to high altitudes, the plant blooms late in spring and is also resistant to late spring frosts. Aronia blooms late in spring and is quite resistant to late spring frosts (Strik et al., 2003; Cujic et al., 2018; Jurendic and Scetar, 2021). Although it is cultivated at temperatures down to -29 and -350 C (Tolić et al., 2017; Cujic et al., 2018; Jurendic and Scetar, 2021), the plants are sensitive to frost in late April/early May, when flower formation occurs. For this reason, the plant is planted in early spring, but if mulching is possible, the plant can also be planted in autumn (Ekiert et al., 2021).

The plant, which has good productivity and quality in sunny areas (Yurtkulu, 2022), shows vegetative development at minimum 60 C, maximum 350 C and average 15-250 C temperatures (Tolić et al., 2017). Although the exact cooling requirement is not fully determined, it has been reported to be approximately 800–1000 hours according to Engin et al. (2018). The air temperatures where the plant is grown, sunlight status and rainfall amounts significantly affect the phenolic and flavonoid ratios especially in the fruit content (Kalt, 2005; Tolić et al., 2017). The water requirement of the plant is no different from other plants and it is of great importance that the rainfall decreases during the vegetation period. The plant, which has the opportunity to grow in places with an annual rainfall of 500-600 mm, can be subjected to drip and irrigation, especially in the months (July and August) when there is water shortage during the fruit growth periods (Yurtkulu, 2022).

Although the perennial and bush-like grape plant with high adaptability can grow in almost all types of soil, the most preferred soils are those that do not have drainage problems, are moist, have medium texture, are rich in organic matter and have a pH value of 6-6.5 (Çelik et al., 2022; Yurtkulu, 2022). The addition of organic substances such as 4-5 tons of compost and well-rotted barn manure to the soil a year before significantly increases the yield of the plant. When necessary, chemical fertilization is also done in order to increase the vegetative development of the plant, and it would be appropriate to divide the amount into two in June and July and give 2.0 and 2.5 kg da^{-1} N and 5-6 kg da^{-1} P_2O_5 in the first year before planting.

6. Areas of Use in Animal Husbandry

In recent years, the global interest in healthy and natural nutrition has significantly increased, leading to a heightened focus on the use of alternative sources in animal production. For this purpose, the idea of aronia plant as a quality roughage source or usability in animal production has come to the fore thanks to both its polyphenol content and biologically active components that support digestion, and the studies conducted on the subject are briefly given below under subheadings.

Use in the meat industry

Today, many products are used to reduce the negative situations in processed meat products and to support their nutritional value (Shan et al. 2017). In particular, changes in color, taste and odor that lead to oxidation are the most important negative factors in the preference of meat and meat products by consumers (Bellucci et al., 2022). Although these negative effects that cause oxidation can be prevented with antioxidants such as synthetic propyl gallate (PG), tert-butylhydroquinone (TBHQ), butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (Granato et al., 2017; Lorenzo et al., 2019), they can have negative effects on the health of consumers. For this reason, the use of natural antioxidants instead of synthetic antioxidants has recently come to the fore in order to regulate lipid and protein oxidation. (Nikmaram et al., 2018). For this purpose, blueberries, blackberries, cranberries and the aronia plant, which has attracted great attention recently, stand out with their rich antioxidant content.

Use in the dairy industry

Today, in recent years, there has been a significant increase in people's demand for functional foods in their dietary preferences, which have significant effects on their health, mental state or physical performance (Rincón-León, 2003). These natural functional foods, which possess antimicrobial, antioxidative, antihypertensive, antidiabetic, immunomodulatory, and antithrombotic activities, may represent an economical and accessible approach to promoting sustainable well-being (Terpeu et al., 2019). Blackberry, raspberry, blackcurrant, blueberry and elderberry are the most preferred and developed bioactive products in fruit-added dairy products (such as fermented milks, kefir and yogurt) within the functional groups (Ozdemir & Ozkan, 2020). Similarly, aronia fruit and its extract, pulp, juice, powder, tea, yogurt, kefir and fermented milk are widely used by people today due to its antioxidant, anti-inflammatory, antidiabetic, anticarcinogenic, antimutagenic, antibacterial, hypolipidemic, cardioprotective and hepatoprotective properties.

Use in improving the growth and meat quality of weaned piglets

Weaning of piglets, which significantly affects intestinal development and growth performance, causes oxidative reactions that lead to economic losses and deterioration in meat quality (Bai et al., 2020). In order to eliminate these negativities, the use of aronia plant, which has a rich polyphenol content, as a feed additive has been recorded to increase both the average daily feed intake (ADFI) and average daily gain (ADG) of weaned piglets and improve meat quality (Liu et al., 2021).

Use in improving egg quality in chickens

Since it is highly preferred by humans worldwide in terms of the protein, lipid, amino acid and minerals it contains, it has been recorded that oxidative stress occurs due to the continuous egg laying of laying hens during the peak laying period and as a result, the egg laying rate and cycle in chickens decreases (Zmrhal et al. 2023). However, in many studies, it has been suggested that some substances with different antioxidant content can increase the egg laying rate in chickens in order to eliminate such negative effects (Frizzell et al., 2017; Gao et al., 2020.; Chen et al., 2021). In fact, in the study conducted by Jing et al. (2024), it was stated that aronia used in the diets of laying hens both increases the antioxidant capacity of the chickens and positively affects the quality of the eggs and meat obtained.

Use of Aronia pulp

In our country, especially in the Eastern Anatolia Region, the use of products as silage has a special importance in terms of meeting the need for quality roughage of animals. While the use of corn, alfalfa, sainfoin, vetch, sorghum and meadow grasses as silage is widespread, the use of agricultural residues as silage has recently become widespread. In particular, due to its high bioactive compounds, polyphenol, carotenoid and fiber content (Lalas et al., 2019; Zhou et al., 2019), fruit pulps obtained from many plant materials such as apple, peach (Büyükkılıç Beyzi et al., 2018) as well as the aronia plant, the remaining part of which is evaluated as silage after the juice is extracted, are widely used for this purpose (Koç et al,. 2023).

7. Conclusion

According to the studies, although the plant leaves contain sufficient fiber and protein, they have lower nutritional content compared to quality roughage sources such as alfalfa and vetch, which are traditionally used in animal nutrition. Consequently, it is increasingly recognized that the most promising application of aronia lies not in its use as a primary forage source, but rather as a functional additive incorporated into animal feeds and products. Such utilization has the potential to significantly enhance the nutritional value, health benefits, and overall quality of animal-derived products, including meat, milk, and eggs. Furthermore, future research is warranted to optimize the inclusion rates, evaluate long-term effects, and explore the economic feasibility of aronia-based additives in diverse livestock production systems.

References

Anonymous. (2021). Aronya Fizibilite Raporu ve Yatırımcı Rehberi. T.C. Tarım ve Orman Bakanlığı Bitkisel Üretim Genel Müdürlüğü Eğitim ve Yayın Dairesi Başkanlığı, 50 s. Ankara.

Ara, V. (2002). Schwarzfruchtige Aronia: Gesund – und bald „in aller Munde“? Flüssiges Obst, 10, 653–658.

Bai, M., Wang, L., Liu, H., Xu, K., Deng, J., Huang, R., & Yin, Y. (2020). Imbalanced dietary methionine-to-sulfur amino acid ratio can affect amino acid profiles, antioxidant capacity, and intestinal morphology of piglets. Animal Nutrition, 6, 447–456.

Bellucci, E. R. B., Santos, J. M. D., Carvalho, L. T., Borgonovi, T. F., Lorenzo, J. M., & Silva Barretto, A. C. (2022). Açaí extract powder as natural antioxidant on pork patties during refrigerated storage. Meat Science, 184, Article 108667.

Benvenuti, S., Pellati, F., Melegari, M., & Bertelli, D. (2004). Polyphenols, anthocyanins, ascorbic acid, and radical-scavenging activity of Rubus, Ribes, and Aronia. Food Chemistry, 88(4), 503–510.

Chen, F., Zhang, H., Du, E., Jin, F., Zheng, C., Fan, Q., … Huang, S. (2021). Effects of magnolol on egg production, egg quality, antioxidant capacity and intestinal health in laying hens during the late laying period. Poultry Science, 100(2), 835–843.

Chrubasik, C., Li, G., & Chrubasik, S. (2010). The clinical effectiveness of chokeberry: A systematic review. Phytotherapy Research, 24, 1107–1114.

Cujic, N., Kardum, N., Šavikin, K., Zdunic, G., Jankovic, T., & Menkovic, N. (2018). Potential of chokeberry (Aronia melanocarpa L.) as a therapeutic food. In A. M. Holban & A. M. Grumezescu (Eds.), Handbook of food bioengineering (Vol. 8, pp. 209–237). Elsevier.

Çelik, H., Karabulut, B. & Uray, Y., (2022). Uluslararası Tarım Araştırmalarında Yenilikçi Yaklaşımlar Dergisi/International Journal of Innovative Approaches in Agricultural Research, 2022, Vol. 6 (3), 246-254.

Ekiert, H., Kubica, P., & Szopa, A. (2021). Successful cultivation and utilization of Aronia melanocarpa (Michx.) Elliott (black chokeberry), a species of North-American origin, in Poland and the biosynthetic potential of cells from in vitro cultures. In M. P. Sharma (Ed.), Medicinal plants, sustainable development and biodiversity (pp. 69–111). Springer. https://doi.org/10.1007/978-3-030-74779-4_4

Ekiert, H. M., Szopa, A., & Kubica, P. (2021). High depside and other phenolic acid production in different shoot cultures of three Aronia species (*A. melanocarpa, A. arbutifolia, A. × prunifolia*). In Plant cell and tissue differentiation and secondary metabolites (pp. 337–364). Springer.

Engin, S.P., Boz, Y., Mert, C., Fidancı, A. & İkinci, A. (2018). Growing Aronia Berry (Aronia melanocarpa (Michx.) Elliot). 1. Internatıonal GAP Agrıculture & Lıvestock Congress 25-27 April 2018 – Şanlıurfa/Türkiye.

Ergül, M., & Akkan, S. (1986). Narenciye posasından yem olarak yararlanma olanakları. Hasad Dergisi, Aralık, 23–25.

Eskimez, İ., & Polat, M. (2023). Aronya (*Aronia melanocarpa* (Michx.) Elliott)'nın mikroçoğaltımında bitki büyüme düzenleyicilerinin etkileri. Meyve Bilimi, 10(Özel Sayı), 92–99.

Fidancı, A. (2015). Türkiye için yeni bir minör meyve: Aronya bitkisi ve yetiştirme teknikleri. In VII. Ulusal Bahçe Bitkileri Kongresi Bildirileri, Bahçe (Özel Sayı 1): Meyvecilik (pp. 1177–1180).

Frizzell, K. M., Lynch, E., Rathgeber, B. M., Dixon, W. T., Putman, C. T., & Jendral, M. J. (2017). Effect of housing environment on hen meat quality: Evaluation of pectoralis major pH, color, and tenderness in three strains of 80- to 81-week-old laying hens housed in conventional and furnished cages. British Poultry Science, 58(1), 50–58.

Gao, S., Li, R., Heng, N., Chen, Y., Wang, L., Li, Z., … Xing, K. (2020). Effects of natural astaxanthin from Haematococcus pluvialis supplementation on antioxidant capacity, lipid metabolism, and deposition in egg yolks of laying hens. Poultry Science, 99(11), 5874–5882.

Granato, D., Nunes, D. S., & Barba, F. J. (2017). An integrated strategy between food chemistry, biology, nutrition, pharmacology, and. statistics in the development of functional foods: A proposal. Trends in Food Science & Technology, 62, 13–22.

Hardin, J. W. (1973). The enigmatic chokeberries (*Aronia, Rosaceae*). Bulletin of the Torrey Botanical Club, 100, 178–184.

Jinga, B., Wu, H., Liu, Z., Shang, H., Li, Y., Jin, Z., & Song, H. (2024). Effects of Aronia melanocarpa dietary supplementation on production performance, meat and egg quality, egg-yolk volatiles and antioxidant capacity in laying hens. Journal of Applied Animal Research, 52(1), 1–12.

Jurendić, T., & Ščetar, M. (2021). Aronia melanocarpa products and by-products for health and nutrition: A review. Antioxidants, 10, 1052.

Kalt, W. (2005). Effects of production and processing factors on major fruit and vegetable antioxidants. Journal of Food Science, 70, R11–R19.

Kaskoniene, V., Bimbiraite, A. & Venskutonis, P. R. (2009). Phenolic compounds and antioxidant activity of small fruits. Journal of Food Research.

Kiselova, Y., Ivanova, D., Chervenkov, T., Gerova, D., Galunska, B., & Yankova, T. (2006). Correlation between the in vitro antioxidant activity and polyphenol content of plant extracts. Phytotherapy Research, 20(11), 961–965.

Koç, F., Erten, K., & Coşkuntuna, L. (2023). Aronya posasının hayvan beslemede kullanım olanakları. Türk Tarım ve Doğa Bilimleri Dergisi, 11(1), 267–278.

Kokotkiewicz, A., Jaremicz, Z., & Luczkiewicz, M. (2010). Aronia plants: A review of traditional use, biological activities, and perspectives for modern medicine. Journal of Medicinal Food, 13, 255–269.

Kulling, S. E., & Rawel, H. M. (2008). Chokeberry (*Aronia melanocarpa*)—A review on the characteristic components and potential health effects. Planta Medica, 74, 1625–1634.

Lehmann, H. (1990). Die Aroniabeere und ihre Verarbeitung. Flüssiges Obst, 57, 746–752.

Liu, X. Z., Ju, Y., Luo, Y. L., Huang, L. L., Cao, N. X., Liu, M. Z., … Yan, Y. (2021). Effects of polyphenol-rich Aronia melanocarpa pomace feeding on growth performance, biochemical profile, and meat quality in pigs at weaned and finishing stages. Livestock Science, 252, 1–9.

McKay, S. A. (2001). Demand increasing for aronia and elderberry in North America. New York Fruit Quarterly, 9(1), 2–3.

Nikmaram, N., Budaraju, S., Barba, F. J., Lorenzo, J. M., Cox, R., Mallikarjunan, K., & Roohinejad, S. (2018). Application of plant extracts to improve the shelf-life, nutritional and health-related properties of ready-to-eat meat products. Meat Science, 145, 245–255.

Ochmian, I., Grajkowski, J., & Smolik, M. (2012). Comparison of some morphological features, quality and chemical content of four cultivars of chokeberry fruits (*Aronia melanocarpa*). Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 40, 253–260.

Oszmiański, J., & Wojdyło, A. (2005). Aronia melanocarpa phenolics and their antioxidant activity. European Food Research and Technology, 221, 809–813.

Poyraz Engin, S., Mert, C., Fidancı, A., & Boz, Y. (2016). Aronya (*Aronia melanocarpa* (Michx.) Elliot) meyve türünde morfolojik incelemeler. Bahçe, 45(Özel Sayı 2), 71–78.

Razungles, A., Oszmianski, J., & Sapis, J. C. (1989). Determination of carotenoids in fruits of Rosa sp. (Rosa canina and Rosa rugosa) and of chokeberry (Aronia melanocarpa). Journal of Food Science, 54, 774–775.

Secher, D. (2008). Fruit with potential for Wisconsin farms. Center for Integrated Agricultural Systems. http://www.cias.wisc.edu/wp-content/uploads/2008/07/carandale.pdf

Shan, L. C., De Brún, A., Henchion, M., Li, C., Murrin, C., Wall, P., & Monahan, F. J. (2017). Consumer evaluations of processed meat products reformulated to be healthier: A conjoint analysis study. Meat Science, 131, 82–89.

Slimestad, R., Torskangerpoll, K., Nateland, H. S., Johannessen, T., & Giske, N. H. (2005). Flavonoids from black chokeberries, Aronia melanocarpa. Journal of Food Composition and Analysis, 18(1), 61–70.

Šnebergrová, J., Čížková, H., Neradová, E., Kapci, B., Rajchl, A., & Voldřich, M. (2014). Variability of characteristic components of aronia. Czech Journal of Food Sciences, 32, 25–30.

Stralsjo, L., Ahlin, H., Witthoft, C. M., & Jastrebova, J. (2003). Folate determination in Swedish berries by radioprotein-binding assay (RPBA) and high-performance liquid chromatography (HPLC). European Food Research and Technology, 216, 264–269.

Strigl, A. W., Leitner, E., & Pfannhauser, W. (1995). Die schwarze Apfelbeere (Aronia melanocarpa) als natürliche Farbstoffquelle. Deutsche Lebensmittel-Rundschau, 91, 177–180.

Strik, B., Finn, C., & Wrolstad, R. (2003). Performance of chokeberry (*Aronia melanocarpa*) in Oregon, USA. In P. Hicklenton & J. Maas (Eds.), Acta Horticulturae 626: Berry crop breeding (pp. 447–451). International Society for Horticultural Science.

Tan, M., & Temel, S. (2012). Alternatif yem bitkileri [Alternative forage crops] (Yayın No. 246). Atatürk Üniversitesi Ziraat Fakültesi.

Tanaka, T., & Tanaka, A. (2001). Chemical components and characteristics of black chokeberry. Journal of the Japanese Society for Food Science and Technology, 48, 606–610.

Tolić, M. T., Krbavčić, I. P., Vujević, P., Milinović, B., Jurčević, I. L., & Vahčić, N. (2017). Effects of weather conditions on phenolic content and antioxidant capacity in juice of chokeberries (*Aronia melanocarpa* L.). Polish Journal of Food and Nutrition Sciences, 67(1), 67–74.

TÜİK. (2024). Hayvansal üretim istatistikleri [Animal production statistics]. https://istatistik.tarimorman.gov.tr/sayfa/detay/1934

Walther, E., & Müller, S. (2012). Aronia, Apfelbeere (*Aronia melanocarpa* [Michx.] Elliott). In B. Hoppe (Ed.), Handbuch des Arznei- und Gewürzpflanzenbaus (Band 4, pp. 95–110). Verein für Arznei- und Gewürzpflanzen Saluplanta.

Wu, X. L., Gu, L. W., Prior, R. L., & McKay, S. (2004). Characterization of anthocyanins and proanthocyanidins in some cultivars of Ribes, Aronia, and Sambucus and their antioxidant capacity. Journal of Agricultural and Food Chemistry, 52, 7846–7856.

Yılmaz, A., Güler, E., Soydemir, H. E., Demirel, S., Mollahaliloğlu, S., Çiftçi, V., & Karadeniz, T. (2021). Miracle plant: Black chokeberry (*Aronia melanocarpa*). MAS Journal of Applied Sciences, 6(1), 83–94.

Yurtkulu, V. (2022). Aronya fizibilite raporu ve yatırımcı rehberi. T.C. Tarım ve Orman Bakanlığı Bitkisel Üretim Genel Müdürlüğü.

Zmrhal, V., Svoradova, A., Venusova, E., & Slama, P. (2023). Effects of heat stress on the immune system of chickens and mitigation of adverse effects by baicalin and baicalein. Animals, 13(16), 2564.