HARRAN ÜNİVERSİTESİ VETERİNER FAKÜLTESİ DERGİSİ

The Effect of the Addition of Different Rates of Sumac (*Rhus coriaria)* Powder to Maize on Silage Fermentation and Aerobic Stability

Besime DOĞAN DAŞ[1,a,*]

[1]Harran Üniversitesi, Veteriner Fakültesi, Hayvan Besleme ve Beslenme Hastalıkları Anabilim Dalı, Şanlıurfa, Türkiye.

[a]ORCİD: 0000-0003-2163-2632

Received: 25.03.2023

Accepted: 02.05.2023

How to cite this article: Doğan Daş B. (2023). The Effect of the Addition of Different Rates of Sumac (*Rhus coriaria)* Powder to Maize on Silage Fermentation and Aerobic Stability. Harran Üniversitesi Veteriner Fakültesi Dergisi, 12(1): 53-57, DOI:10.31196/huvfd.1270861.

***Correspondence:** Besime DOĞAN DAŞ
Harran Üniversitesi, Veteriner Fakültesi, Hayvan Besleme ve Beslenme Hastalıkları Anabilim Dalı, Şanlıurfa, Türkiye.
e-mail: bdas@harran.edu.tr

Available on-line at: https://dergipark.org.tr/tr/pub/huvfd

Abstract: This study aims to determine the effects of adding different rates of sumac powder to maize (0%, 0.5%, 1%, and 2%) on fermentation properties, silage quality, and aerobic stability. In the study, 16 silage samples, four repetitions from each group, were placed in 1.5-liter glass jars and compressed. Silages were left to ferment for 60 days. In addition, the silages were subjected to an aerobic stability test for five days immediately after opening. The lowest CO_2 value was determined in the 0.5% sumac group (*P<0.05*). The pH values of the silages were determined between 3.65 and 3.74 (*P<0.05*). Silages were evaluated as high quality according to the Flieg scoring system. The addition of sumac powder to maize increased the number of lactic acid bacteria by reducing the total yeast mold with the formation of carbon dioxide (*P<0.05*). As a result, it was determined that adding sumac powder to maize positively affects silage fermentation, improves aerobic stability, and increases lactic acid bacteria by preventing total yeast mold formation. As a result of the research, it was determined that using 1% and 2% sumac powder while making maize silage can increase silage quality characteristics. It was concluded that this study should be supported by *in vitro* and *in vivo* trials.
Keywords: *Aerobic stability, Corn silage, Silage fermentation, Sumac.*

Mısır Silajına Farklı Oranlarda Sumak (*Rhus coriaria*) Tozu İlavesinin Silaj Fermantasyonu ve Aerobik Stabilite Üzerine Etkisi

Özet: Bu araştırmanın amacı, mısır hasılına farklı (%0, %0.5, %1 ve %2) oranlarda sumak tozu ilavesinin fermantasyon özellikleri, silaj kalitesi ve aerobik stabilite üzerine etkilerini belirlemektir. Araştırmada, her gruptan 4 tekerrür olmak üzere toplam 16 adet silaj örneği 1.5 litrelik cam kavanozlara konularak sıkıştırılmıştır. Silajlar 60 gün süresince fermantasyona bırakılmıştır. Ayrıca, silajlar açıldıktan hemen sonra 5 gün süre ile aerobik stabilite testine tabi tutulmuştur. En düşük CO_2 değeri %0,5 sumak grubunda belirlenmiştir (P<0.05). Silajların pH değerleri 3.65 ile 3.74 arasında belirlenmiştir (P<0.05). Flieg puanlama sistemine göre silajlar kaliteli olarak değerlendirilmiştir. Mısır hasılına sumak tozu ilavesi, karbondioksit oluşumu ve toplam maya küf sayısını azaltarak, laktik asit bakteri sayısını arttırmıştır (P<0.05). Sonuç olarak mısır hasılına sumak tozunun katılmasının, silaj fermantasyonunu olumlu yönde etkilediği, aerobik stabiliteyi iyileştirdiği ve toplam maya küf oluşumunu engelleyerek, laktik asit bakterilerini artırdığı belirlenmiştir. Araştırma sonucunda mısır silajı yapılırken %1 ve %2 seviyelerinde sumak tozunun kullanılmasının silaj kalite özelliklerini artırabileceği belirlenmiştir. Yapılan bu çalışmanın *in vitro* ve *in vivo* denemelerle desteklenmesi gerektiği kanısına varılmıştır.
Anahtar Kelimeler: *Aerobik stabilite, Mısır silajı, Silaj fermantasyonu, Sumak*.

Introduction

One of the most essential issues for livestock farmers is the quality of the roughage. Roughage is an important part of livestock farming. Silage production is emphasized to ensure the balanced nutrition of ruminants in winter and to meet the need for high-quality roughage (Keskin et al., 2016). Maize silage is the world's most widely used silage in silage production (Borreani et al., 2018; García-Chávez et al., 2020).

Recently, the interest in natural products has brought up the use of aromatic plants and products obtained from there in food, animal nutrition, and medicine. However, there is limited research on using these aromatic plants and extracts as silage additives (Chaves et al., 2012; Kung et al., 2008; Önenç et al., 2015; Turan, 2015).

Studies on the nutrition of ruminants have shown that phenolic and flavonoids- containing plants are significant in terms of rumen health and animal productivity (Formato et al., 2022; Lee et al., 2017; Rochfort et al., 2008). Dohi et al. (1997) reported that feed intake and, thus, animal yield increased in animals fed with plants containing phenolic compounds. Santos-Neto et al. (2009) and Frozza et al. (2013) stated that these compounds have antioxidant and antimicrobial effects and reported that flavonoids and phenolic compounds also control nutritional stresses such as rumen fermentation, bloat and acidosis (Paula et al., 2016; Seradj et al., 2014) and that phenolic compounds both promote fermentation in silage and give an aromatic taste to silage (Gülümser et al., 2022).

Sumac, often called as *Rhus coriaria* L., is a Mediterranean plant member of the Anacardiaceae family and is usually employed as a spice and flavoring (Batiha et al., 2022; Rayne and Mazza, 2007). Sumac contains various compounds such as organic acids, proteins, essential oils, minerals, vitamins, and phenolics. Sumac has an important antioxidant role as it is rich in phenolic compounds, especially gallic acid and its derivatives (Rad et al., 2020; Sakhr and Khatib, 2020).

This study determined the effects of adding different rates (0%, 0.5%, 1%, and 2%) of sumac powder to corn green as an antimicrobial additive on silage quality and fermentation properties.

Materials and Methods

Corn green was used as silage material in the study. Corn green was ensiled by adding 0%, 0.5%, 1%, and 2% sumac powder at different rates. In the experiment, four groups were formed. A total of 16 silage samples, four of which were repetitions from each group, were compressed into 1.5-liter glass jars. The caps of the glass jars were drilled, the jars were inverted, and silo water drainage was provided for 48 hours. The jars were opened after a 60-day incubation period. The pH values were measured immediately after the opening the silages (Polan et al., 1998). Ammonia nitrogen analyses were performed according to the method reported by Broderick and Kang (1980). Dry matter (DM), crude protein (CP) and crude ash (CA) analyzes were performed according to the Weende analysis system (AOAC, 2005), and ADF and NDF analyzes were performed according to the method reported by Van Soest et al. (1991). The silages opened were subjected to an aerobic stability test (determination of CO_2 production values) (Ashbell et al., 1991). The LAB, total yeast mold counts of the silages made by the method developed by Seale et al. (1990). Fleig scoring of silages was calculated with the equation of

Fleig Score = 220 + (2 x % Dry Matter - 15) - 40 x pH reported by Kılıç (1984).

The data obtained at the end of the study were evaluated with a one-way analysis of variance (One Way ANOVA) in the SPSS (2008) software program. Duncan's multiple comparison tests were used to compare the mean scores between the groups.

This study is not subject to Ethics Committee permission under Article 8 (k2) of the "Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees".

Results

DM, CA, CP, ADF, and NDF values of corn silage used in the study were found to be 27.22%, 7.83% DM, 10.54% DM, 32.39%, and 57.11% DM, and sumac powder was found to be 96.68%, 2.64% DM, 3.1% DM, 27.17 and 61.29% DM, respectively.

The nutrient contents of corn silage with different amounts of sumac powder are given in Table 1. When Table 1 was examined, there was no statistically significant difference between the DM, CA, and CP values of the silage groups (*P>0.05*), while there was a statistically significant difference between the ADF and NDF values (*P<0.05*). In addition, ADF values increased in parallel with the increase in sumac powder.

Table 1: The nutrient content of the corn silages with different amounts of sumac powder.

	DM	CA	CP	ADF	NDF
Control	26.69	7.54	7.36	32.46^{c}	59.41^{b}
0.5% Sumac	26.44	7.84	7.15	36.03^{b}	59.11^{b}
1% Sumac	27.06	7.44	7.83	35.66^{b}	63.18^{a}
2% Sumac	27.00	7.81	7.29	38.73^{a}	62.93^{a}
SEM	0.128	0.120	0.097	0.585	0.611
P	0.300	0.611	0.056	**0.000**	**0.005**

$^{a-c}$Values with different letters in the same column were found to be different (*P<0.05*), **SEM:**Standart Error of Mean; **DM:** Dry matter, %; **CA:** Crude ash, DM%, **CP:** Crude protein, DM%, **ADF:** Acid detergent fiber, DM%; **NDF:** Neutral detergent fiber, DM%.

The fermentation characteristics, Fleig scores, total yeast mold, and lactic acid bacteria counts of the silages obtained by adding sumac powder were given in Table 2. While there was a statistically significant difference between the groups in terms of pH, NH_3-N, CO_2, total yeast mold, and lactic acid bacteria counts of silages in all groups (*P<0.05*), there was no statistically significant difference between the Fleig scores (*P>0.05*). The pH values of the silages obtained were determined between 3.65 and 3.74. Fleig scores were determined to be above 100 points. In parallel with the increase in sumac powder, a decrease was observed in total yeast and mold values (*P<0.05*).

Table 2: The effect of corn silages prepared by adding sumac powder at different rates on the fermentation properties and silage quality.

	pH	NH_3-N	CO_2	Fleig	Total Yeast-Mold cfu/g	LAB kob/g
Control	3.65^c	8.57^b	3.00^a	111.51	8.35^a	6.85^b
0.5% Sumac	3.65^c	9.47^a	1.70^c	110.63	8.35^a	7.14^{ab}
1% Sumac	3.68^b	8.03^b	1.97^{bc}	112.47	7.73^{ab}	8.30^a
2% Sumac	3.74^a	8.51^b	2.41^{ab}	111.30	6.95^b	8.26^a
SEM	0.011	0.185	0.155	0.528	0.197	0.237
P	**0.000**	**0.024**	**0.003**	0.714	**0.015**	**0.033**

$^{a-c}$;Values with different letters in the same column were found to be different (*P<0.05*), **SEM:**Standart Error of Mean; **CO_2:** Carbon dioxide formation, g/kg DM, **NH_3-N/TN:** Ammonia nitrogen rate in total nitrogen (TN) content % NH_3-N/TN, **LAB:** Lactic Acid Bacteria cfu/g.

Discussion and Conclusion

The results obtained from nutrient analysis of silages opened after 60 days showed no increase in DM values. This may be due to the low rates of sumac powder added to maize. DM values of maize silages in the current study are within the ranges of the values for quality silages (20-35%) reported by Ergül (1993). There was no statistically significant difference between the crude ash values of the silages. In addition, there was no difference between the groups in the crude protein values of the silages, and it was concluded that this might be due to the low crude ash and crude protein values of the sumac material used.

The ADF and NDF values of the silages obtained increased in parallel with the increase in sumac addition (*P<0.05*). The ADF rate refers to the amount of cellulose, lignin, and insoluble protein in the structure of the plant cell wall. The ADF rate is a good indicator that gives an idea about the digestibility of the feed and the energy intake of the animal. The NDF rate refers to the whole fiber in the plant, including hemicellulose and fiber (Seydoşoğlu and Gelir, 2019). In the present study, the increase in ADF and NDF can be attributed to the high cell wall elements in sumac powder.

When silage ammonia nitrogen values were examined, all values obtained lower than 11%. Carpintero et al. (1979) reported that silage ammonia nitrogen being lower than 11% referred that silages were in good quality silage class.

The change between the Flieg scores calculated by using the DM and the silage pH values was not statistically significant (*P>0.05*). In all experimental groups, the values were determined to be above 100 points, and it was determined that the silages were in the Excellent class. Since it is an easily ensiled plant, no additives are required for the silage of maize (Güney et al., 2010). For this reason, the control group was also included in the class of quality silages according to the Flieg score. In addition, the very low ratio of sumac in silages, may have caused no difference between the groups. According to the Flieg scoring system, it is seen that there is a strong relationship between DM values, pH values, and Flieg scores of silages (Yalçınkaya et al., 2012).

The first few days of ensiling are critical for good fermentation. Under favorable conditions, lactic acid bacteria rapidly acidify silage, reducing pH and preventing the development of unwanted microorganisms, especially *enterobacteria, clostridia*, and yeasts (McDonald et al., 1991). The pH of the silages obtained in this study was between 3.65-3.74 and was among the required pH values. When Table 2 is examined, it is seen that the low pH values of silages decrease the total yeast mold growth and increase the number of lactic acid bacteria (LAB) (Filya, 2018; Guan et al., 2021). In silage fermentation, LAB is the essential microorganism because silo feed is protected by the lactic acid produced by LAB (McDonald et al., 1991). The main point of improving the silage quality is the increased number of LAB. Therefore, the increase in LAB in the treatment groups in this study indicates that adding sumac powder effectively improves the quality of silage.

In this study conducted, when the carbon dioxide value of the silages was examined, it was determined that the lowest carbon dioxide value (1.70 g/kg DM) was 0.5% sumac powder addition in the experimental group. Accordingly, it was observed that silages with 0.5% sumac powder added improved aerobic stability (*P<0.05*). Similarly, Önenç et al. (2019) determined the effects of adding thyme and cumin essential oil to alfalfa on fermentation quality and aerobic stability.They found that adding of thyme and cumin essential oil significantly reduced pH, water-soluble carbohydrate, and ammonia nitrogen, increased dry matter and lactic acid contents, decreased yeast and mold counts, and increased lactic acid bacteria counts. They reported that adding of thyme and cumin essential oils to alfalfa 650 mg/kg promotes silage fermentation and improves aerobic stability. This report supports our study wherein adding of sumac (0.5%, 1%, and 2%) to maize silage reduced the total number of yeast molds and increased the number of lactic acid bacteria.

As a result of the research, it was determined that adding different rates (0.5%, 1%, and 2%) of sumac powder reduced the number of silage yeasts and molds with CO_2 production and improved aerobic stability by increasing the number of LAB. Due to these positive effects, sumac powder can be added at 1% and 2% levels while making maize silage. However, it was concluded that this study should be supported by in *vitro* and *in vivo* trials.

Conflict of Interest

The authors stated that they did not have anyreal, potential or perceived conflict of interest.

Ethical Approval

This study is not subject to HADYEK's permission in accordance with Article 8 (k) of the "Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees".

Similarity Rate

We declare that the similarity rate of the article is 12% as stated in the report uploaded to the system.

Author Contributions

Motivation / Concept: BDD
Design: BDD
Control/Supervision: BDD
Data Collection and / or Processing: BDD
Analysis and / or Interpretation: BDD
Literature Review: BDD
Writing the Article: BDD
Critical Review: BDD

References

AOAC, 1990: Official methods of analysis, Association of official analytical chemists, Washington DC.

Ashbell G, Weinberg ZG, Azrieli A, Hen Y, Horev B, 1991: A simple system to study the aerobic determination of silages. *Can Agric Eng*, 34, 171-175.

Batiha GES, Ogunyemi OM, Shaheen HM, Kutu FR, Olaiya CO, Sabatier JM, De Waard M, 2022: Rhus coriaria L.(Sumac), a versatile and resourceful food spice with cornucopia of polyphenols. *Molecules*, 27 (16), 5179.

Borreani G, Tabacco E, Schmidt RJ, Holmes BJ, Muck RE, 2018: Silage review: Factors affecting dry matter and quality losses in silages. *J Dairy Sci*, 101 (5), 3952-3979.

Broderick GA, Kang JH, 1980: Automated simultaneous determination of ammonia and total amino acids in ruminal fluid and in vitro media. *J Dairy Sci*, 63 (1), 64-75.

Carpintero CM, Henderson AR, McDonald P, 1979: The effect of some pre-treatments on proteolysis during the ensiling of herbage. *Grass Forage Sci*, 34, 311-315.

Chaves AV, Baah J, Wang Y, McAllister TA, Benchaar C, 2012: Effects of cinnamon leaf, oregano and sweet orange essential oils on fermentation and aerobic stability of barley silage. *J Sci Food Agric*, 92, 906-915.

Güney E, Tan M, Gül Z D, Gül İ, 2010: Erzurum şartlarında bazı silajlık mısır çeşitlerinin verim ve silaj kalitelerinin belirlenmesi. *Atatürk Üniv Ziraat Fak Derg*, 41 (2), 105-111.

Dohi H, Yamada A, Fukukawa T,1997: Intake stimulants in perennial ryegrass (Lolium perenne L.) fed to sheep. *J Dairy Sci*, 80, 2083–2086.

Ergül M, 1993: Feeds knowledge and technology. 2nd ed., Ege University Faculty of Agriculture Publications, İzmir.

Filya İ, 2018: Developments in silage fermentation and a future perspective.In: 2nd International Animal Nutrition Congress, Antalya, Türkiye.

Formato M, Cimmino G, Brahmi-Chendouh N, Piccolella S, Pacifico S, 2022: Polyphenols for livestock feed: Sustainable perspectives for animal husbandry? *Molecules*, 27 (22), 7752.

Frozza COS, Garcia CSC, Gambato G, de Souza MD, Salvador M, Moura S, Padilha FF, Seixas FK, Collares T, Borsuk S, Dellagostin OA, Henriques JA, Roesch-Ely M, 2013: Chemical characterization, antioxidant and cytotoxic activities of brazilian red propolis. *Food Chem Toxicol*, 52, 137-142.

García-Chávez I, Meraz-Romero E, Castelán-Ortega O, Esparza JZ, Avalos JO, Jimenez LER, González-Ronquillo M, 2020: Corn silage, meta-analysis of the quality and yield of different regions in the world. *Preprints*, 2020100094.

Guan H, Ran Q, Li H, Zhang X, 2021: Succession of microbial communities of corn silage inoculated with heterofermentative lactic acid bacteria from ensiling to aerobic exposure. *Fermentation*, 7 (4), 258.

Gülümser E, Mut H, Başaran U, Doğrusöz MÇ, 2022: Hop (Humulus lupulus L.) as a Roughage Source. *Bilecik Seyh Edebali Univ J Sci*, 9 (1), 609-615.

Keskin B, Yilmaz H, Temel S, Eren B, 2016: Determination of yield and some plant characteristics in some silage corn varieties. In: VII International Scientific Agriculture Symposium," Agrosym 2016", Jahorina, Bosnia and Herzegovina, pp. 803-807.

Kılıç A, 1984: Silage feed. Bilgehan Press, İzmir, Türkiye, pp. 350.

Kung JL, Williams P, Schmidt RJ, Hu W, 2008: A blend of essential plant oils used as an additive to alter silage fermentation or used as a feed additive for lactating dairy cows. *J Dairy Sci*, 91, 4793-4800.

Lee SHY, Humphries DJ, Cockman DA, Givens DI, Spencer JPE, 2017: Accumulation of citrus flavanones in bovine milk following citrus pulp ıncorporation into the diet of dairy cows. *EC Nutr*, 7 (4), 143-154.

McDonald P, Henderson AR, Heron SJE, 1991: The biochemistry of silage. Chalcombe publications, Marlow, UK.

Önenç SS, Koç F, Coşkuntuna L, Özdüven ML, Gümüş T, 2015: The effect of oregano and cinnamon essential oils on fermentation quality and aerobic stability of field pea silages. Asian-australas. *J Anim Sci*, 28 (9), 1281–1287.

Önenç SS, Turgud FK, Uçman AT, 2019: Effects of Oregano and Cumin Essential Oils on Fermentation Quality, Aerobic Stability and In Vitro Metabolic Energy Contents of Alfalfa Silages. *J Anim Prod*, 60 (2), 117-123.

Paula EM, Samensari RB, Machado E, Pereira LM, Maia FJ, 2016: Effects of phenolic compounds on ruminal protozoa population, ruminal fermentation, and digestion in water buffaloes. *Livest Sci*, 185, 136-41.

Polan CE, Stieve DE, Garrett JL, 1998: Protein preservation and ruminal degradation of ensiled forage treated with heat, formic acid, ammonia, or microbial inoculant. *J Dairy Sci*, 81 (3), 765-776.

Rad AH, Khaleghi M, Javadi M, 2020: Sumac in food ındustry: a changing outlook for consumer and producer. *J Food Technol Nutr Sci*, 2 (1), 1-3.

Rayne S, Mazza G, 2007: Biological activities of extracts from sumac (Rhus spp.): a review. *Nat Prec*, 1-1.

Rochfort S, Parker AJ, Dunshea FR, 2008: Plant bioactives for ruminant health and productivity. *Phytochem*, 69 (2), 299–322.

Sakhr K, Khatib SE, 2020: Physiochemical properties and medicinal, nutritional and industrial applications of Lebanese Sumac (Syrian Sumac - Rhus coriaria): A review. *Heliyon*, 6 (1), e03207.

Seale DR, Pahlow G, Spoelstra SF, Lindgren S, Dellaglio F, Lowe JF, 1990: Methods forthe microbiological analysis of silage. In: Proceeding of the Eurobac Conference, Uppsala, Sweden, pp.147.

Seradj AR, Abecia L, Crespo J, Villalba D, Fondevila M, Balcells J, 2014: The effect of Bioflavex® and ıts pure flavonoid components on in vitro fermentation parameters and methane production in rumen fluid from steers given high concentrate diets. *Anim Feed Sci Technol*, 197, 85-91.

Seydoşoğlu S, Gelir G, 2019: Research on the Silage Properties of Grasspea (Lathrus sativus L.) and Barley (Hordeum vulgare L.) Herbages Mixed at Different Rates. *J Inst Sci Technol*, 9 (1), 397-406.

SPPS, 2008: Inc, SPSS Statistics for Windows, Version, Chicago.

Turan A, 2015: Effect of cumın essentıal oıl usage on fermentatıon qualıty and aerobıc stabılıty of alfalfa sılage. Master's thesis, NKU Graduate School of Natural and Applied Science, Tekirdağ.

Van Soest PJ, Robertson JB, Lewis BA, 1991: Methods of dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *J Dairy Sci*, 74, 3583-3597.

Yalçınkaya MY, Baytok E, Yörük MA, 2012: Some Physical and Chemical Properties of Different Fruit Pulp Silages. *Erciyes Üniv Vet Fak Derg*, 9 (2), 95-106.