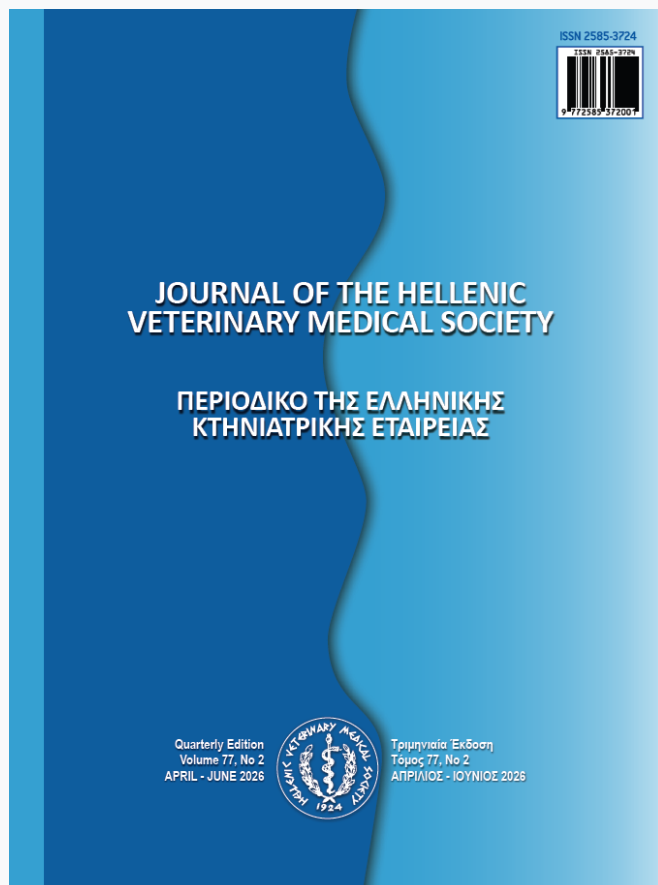


Journal of the Hellenic Veterinary Medical Society

Vol 77, No 2 (2026)



Investigation of Nutrient Content and Digestibility Levels of Mulberry Leaves (*Morus Alba*) Grown in Different Provinces

İ Ulger, T Ayasan, M Kaliber, SB Beyzi, H Inci, ÇÖ Özkan

doi: [10.12681/jhvms.41912](https://doi.org/10.12681/jhvms.41912)

Copyright © 2026, İ Ulger, T Ayasan, M Kaliber, SB Beyzi, H Inci, ÇÖ Özkan



This work is licensed under a [Creative Commons Attribution-NonCommercial 4.0](https://creativecommons.org/licenses/by-nc/4.0/).

To cite this article:

Ulger, İ, Ayasan, T., Kaliber, M., Beyzi, S., Inci, H., & Özkan, ÇÖ. (2026). Investigation of Nutrient Content and Digestibility Levels of Mulberry Leaves (*Morus Alba*) Grown in Different Provinces. *Journal of the Hellenic Veterinary Medical Society*, 77(2), 10477–10484. <https://doi.org/10.12681/jhvms.41912>

Investigation of Nutrient Content and Digestibility Levels of Mulberry Leaves (*Morus Alba*) Grown in Different Provinces

I. Ulger,^{1*} T. Ayasan,^{2*} M. Kaliber,³ S. B. Beyzi,⁴ H. Inci,⁵ C.O. Ozkan⁶

^{1,3,4}Department of Animal Sciences, Faculty of Agriculture, Erciyes University, Kayseri, Türkiye

²Osmaniye Korkut Ata University, Kadirli Faculty of Applied Sciences, Osmaniye, Türkiye

⁵Department of Animal Sciences, Faculty of Agriculture, Bingöl University, Bingöl, Türkiye

⁶Kahramanmaraş Sutcu Imam University, Faculty of Agriculture, Department of Animal Science, Kahramanmaraş, Türkiye

ABSTRACT: This study was conducted to investigate the possibilities of using mulberry leaves collected from 10 different provinces in animal feeding. Dry matter (DM), crude protein (CP), crude ash (CA), acid detergent fiber (ADF), neutral detergent fiber (NDF), crude fat (CF), gas production (GP), organic matter digestibility (OMD) and energy values (ME and NEL) of mulberry leaves collected from different provinces were determined. Gas production of mulberry leaves was determined in 24 h incubation periods and gas production kinetics was explained using the equation $y=A(1-\exp(-ct))$. The highest dry matter (DM) ratio of mulberry leaves was found in mulberry leaves collected from Şanlıurfa (33.18%). The highest CA ratio was determined in mulberry leaves collected from Kayseri (21.25%). The highest CP ratio was found in mulberry leaves collected from Adıyaman (20.96%). The highest CF ratio was found as 4.54% in mulberry leaves collected from Adana. The differences between the provinces in terms of DM, CA, CP, CF contents were statistically significant ($P<0.001$). The ADF rate was found to be the highest as 28.44% in the Aydın group ($P<0.001$). In the study, NDF rate and HEM rate were found to be 35.65% and 18.13%, respectively, in mulberry leaves collected from Niğde ($P<0.001$). While the OMD rate was found as 46.13% in the Adıyaman group, it was found as 59.89% in the Yozgat group. It was found that the difference between the provinces in terms of OMD rate was statistically significant. 24-hour GP values, % methane production, ME, NEL values obtained from mulberry leaves were the highest in mulberry leaves collected from Yozgat as 40.33 ml; 3.46 ml; 9.07 MJ/kg; it was determined as 5.40 MJ/kg ($P<0.05$). As a result, it was seen that the soil structure and climate structure of the region where the mulberry leaves obtained from different provinces are located have a significant effect on the nutritional values. Although there are significant differences in terms of the chemical composition of the mulberry leaves and some estimated parameters, it can be said that the mulberry leaves have high CP content and good digestibility.

Keyword: Mulberry leaves; nutrient; in vitro gas; metabolic energy

Correspondence author:

I. Ulger

Department of Animal Sciences, Faculty of Agriculture,
Erciyes University, Kayseri, Türkiye

E-mail address: i_ulger1@hotmail.com

Date of submission: 26-6-2025

Date of acceptance: 11-7-2025

INTRODUCTION

The demand for alternative forage plants and raw materials has risen in recent years due to the inadequacy of traditional feed raw materials in animal nutrition (Ulger *et al.*, 2017; Ayaşan *et al.*, 2018; Ekizoğlu *et al.*, 2020; Ülger *et al.*, 2020; Ayaşan *et al.*, 2021; Ay *et al.*, 2023; Beyzi *et al.*, 2023; Ülger *et al.*, 2023). In this context, mulberry leaves and their by-products have emerged as one of the feeds that are being focused on and extensively researched (İşbilir & Çelik, 2021; Sarkhel *et al.*, 2021; Ali *et al.*, 2023; Guo *et al.*, 2025; Liu *et al.*, 2025).

The most important characteristic of mulberry leaves is their high protein content. While the crude protein level of mulberry leaves varies between 15-30% on a dry matter basis, the average is 29.80%; this content varies according to a wide range of factors (Ayaşan & Baylan, 2016). Mulberry leaves also stand out as a source used for egg yolk pigmentation due to their beta-carotene content.

Mulberry trees are adaptable to a broad spectrum of climates, terrains, and soil types. Traditionally, their leaves have been used globally as the primary food source for silkworms. The fruit of the mulberry is consumed both fresh and dried and finds applications in making marmalades, juices, liqueurs, natural dyes, and cosmetic products. Among the numerous species of mulberry, the Anatolia Region in Türkiye offers favorable conditions for cultivating high-quality varieties, notably *Morus alba*, *Morus nigra*, and *Morus rubra*. Recently, the use of locally sourced mulberry leaves has gained attention as a potential feed or feed supplement for ruminants and certain monogastric animals, particularly during periods of limited availability of high-quality forage (Phiny *et al.*, 2003; Bamikole *et al.*, 2005; Todaro *et al.*, 2007; Chowdary *et al.*, 2009; Ustundag & Ozdogan, 2023). While the nutritional composition and value of *Morus alba* are well-documented, data concerning the chemical properties and feed potential of other species like *Morus nigra* and *Morus rubra* remain scarce. Additionally, no existing studies report on the biomass yield of mulberry leaves as a ruminant feed resource in Türkiye.

Mulberry leaves contain substantial levels of crude fiber and tannins, which have been reported to negatively influence the health and performance of poultry when included at high levels in their diet (Al-Kirshi *et al.*, 2010). Despite these limitations, mulberry leaves are recognized in traditional medicine for their high nutritional content and notable

antioxidant properties (Krol *et al.*, 2016). According to Cui *et al.*, (2024), while mulberry leaves are rich in essential nutrients, the presence of anti-nutritional factors can impair digestion and nutrient absorption. Their findings suggest that unprocessed mulberry leaves may pose health risks to animals; however, fermentation processes can mitigate these effects by decreasing anti-nutritional compounds and enhancing overall nutritive value. Similarly, Hnokaew *et al.*, (2024) identified mulberry leaf as a promising functional feed or additive capable of promoting beneficial rumen microbiota and improving fermentation parameters in lactating dairy cows without detrimental effects on animal health or productivity. Geng *et al.*, (2024) observed that both fresh and ensiled mulberry leaves could be incorporated into livestock diets without compromising performance or carcass quality. Additionally, Aziz-Aliabad *et al.*, (2025) reported that dietary inclusion of green tea and mulberry leaves in broiler rations improved meat quality, positively modulated ileal microbiota, and reduced serum lipid and malondialdehyde (MDA) levels.

The present study aims to expand existing knowledge on the nutritional value of various mulberry species cultivated in Türkiye by assessing their chemical composition and digestibility using the *in vitro* gas production method. Specifically, this research seeks to evaluate the nutrient profiles and potential digestibility of mulberry leaves collected from different regions of the country, with a focus on their applicability in animal nutrition.

MATERIALS AND METHODS

In this study, mulberry trees growing in different provinces of our country (Adana, Adıyaman, Aydın, Kayseri, Nevşehir, Niğde, Sivas, Şanlıurfa, Uşak and Yozgat) were used. Leaves will be collected from these trees in June-July. Within the scope of the study, mulberry leaves will be collected by hand in 3 replications from 10 different provinces in June-July and brought to the laboratory.

Fresh weights of the collected samples were recorded before they were dried in the shade and then reweighed to determine dry weights. The dried samples were subsequently ground using a 1 mm sieve and stored for chemical analysis. Analyses conducted included dry matter (DM), crude ash (CASH), crude protein (CP), crude fat (CF), crude fiber (CS), acid detergent fiber (ADF), neutral detergent fiber (NDF), and *in vitro* gas production.

The DM, CP, CASH, and CF analyses were performed according to the standard methods outlined by AOAC (1990). The analyses for crude fiber (CS), NDF, and ADF followed procedures developed by Van Soest *et al.*, (1991) and Goering & Van Soest (1975).

The *in vitro* gas production technique described by Menke & Steingass (1979) was employed to evaluate the digestibility and metabolizable energy (ME) content of feedstuffs. Approximately 200 ± 10 mg of each ground feed sample was weighed into 100 mL special glass syringes (Model Fortuna, Häberle Labortechnik, Lonsee Ettlenschieß, Germany) in triplicate. A 30 mL rumen fluid-buffer mixture, prepared following Menke *et al.* (1988), was added to each syringe. Samples were incubated in a water bath maintained at 39°C, and gas production was measured at 3, 6, 12, 24, 48, 72, and 96 hours of incubation. Cumulative gas production data were fitted to the non-linear model of Ørskov & McDonald (1979):

$$y = a + b(1 - e^{-ct})$$

a = gas production from the soluble fraction (ml)

b = gas production from the insoluble fraction (ml)

c = gas production rate constant for the insoluble fraction

a+b = potential gas production (ml)

y = gas volume at time t

Gas production data were analyzed using the Neway

computer program. The metabolizable energy (ME, MJ/kg DM) and digestible organic matter (DOM, %) of feedstuffs were calculated based on Menke & Steingass (1988) using the following equations:

$$\text{ME, MJ/kg KM} = 1.06 + 0.1570 \times \text{GÜ} + 0.0084 \times \text{CP} + 0.0220 \times \text{CF} - 0.081 \times \text{CA}$$

$$\text{SOM, \%} = 9.00 + 0.9991 \times \text{GÜ} + 0.0595 \times \text{CP} + 0.0181 \times \text{CA}$$

ME: metabolic energy,

SOM: digestible organic matter,

GÜ: net gas production after 24 h incubation (mL/200 mg DM)

CP: crude protein (%)

CF: : crude fat (%)

CA: crude ash (%)

All data were analyzed using the General Linear Model (GLM) procedure in SPSS (1997, Chicago, IL, USA). Differences between means were determined by Duncan's multiple range test at a 5% significance level. Results are reported as means \pm standard error of the mean (SEM).

RESULTS AND DISCUSSION

The nutrient composition values of mulberry leaves collected from 10 different provinces in the study are given in Table 1.

The dry matter (DM) values of mulberry leaves collected from different provinces led to a statistical differentiation among the provinces. In our study, the

Table 1. Dry matter, crude ash, crude protein, and crude fat contents of the mulberry leaves used as study material

Province	DM, %	CA, % KM	CP, % KM	CF, % KM
Adana	31.34 ^{b*}	15.48 ^c	15.03 ^c	4.54 ^a
Niğde	30.50 ^c	14.59 ^{cd}	17.56 ^d	2.89 ^d
Sivas	33.08 ^a	10.87 ^e	18.53 ^c	3.05 ^d
Nevşehir	32.68 ^a	15.63 ^c	14.02 ^f	2.65 ^e
Uşak	27.41 ^d	11.15 ^e	20.45 ^b	2.40 ^f
Yozgat	31.20 ^b	10.72 ^e	18.79 ^c	2.94 ^d
Adıyaman	22.71 ^e	16.49 ^c	20.96 ^a	3.34 ^c
Kayseri	30.30 ^c	21.25 ^a	12.14 ^g	3.55 ^b
Aydın	27.26 ^d	13.48 ^d	18.42 ^c	2.64 ^e
Şanlıurfa	33.18 ^a	18.51 ^b	18.38 ^c	3.35 ^c
S.H.	0.584	0.629	0.499	0.109
P	<0.001	<0.001	<0.001	<0.001

P: Statistical significance level; S.H: Standard error of means. *Differences between means shown with different letters in the same column are statistically significant ($p < 0.05$).

highest DM content was determined as 33.18% in mulberry leaves obtained from Şanlıurfa province, while the lowest value was found to be 22.71% in mulberry leaves from Adıyaman province ($P < 0.001$). Güven (2010) determined the DM values of mulberry leaves to be between 25.97-46.27%; Al-Kirshi *et al.* (2010) found the DM of mulberry leaves to be 89.25%; Güven (2012) reported 46.27%; Hnokaew *et al.* (2024) found 91.26%, and Yan *et al.* (2024) determined it to be between 23.2-38.6%. The reasons for differences in the chemical composition of mulberry leaves in various studies are likely due to variations in species, cultivation location, growing conditions, soil, and harvest times of the leaves.

In the study, the crude ash (CA) content led to a statistical differentiation among provinces. The highest crude ash content was found in mulberry leaves collected from Kayseri at 21.25%, while the lowest CA content was detected in mulberry leaves collected from Yozgat at 10.72%. Ayaşan & Baylan (2016) reported the CA content of mulberry leaves as 11.80%; Kandylis *et al.* (2009) found 16.3%; Al-Kirshi *et al.* (2010) determined 5.57%; and Güven (2012) reported 15.40%.

In the study, the highest CP ratio was found to be 20.96% in mulberry leaves collected from Adıyaman, while the lowest CP ratio was found in the Kayseri group with 12.14%. A statistical differentiation in terms of CP was detected among the groups.

Ayaşan & Baylan (2016) reported the CP ratio of mulberry leaves as 29.80%, while Güven (2012) determined CP ratios of mulberry leaves in different species between 11.75% and 23.72%. Yu *et al.* (2018) found it between 27.63-37.36%; Kandylis *et al.* (2009) determined it as 20.1%; Güven (2012) as 18.73%. Ustundag & Ozdogan (2023) found it to be 20.0%, while Hnokaew *et al.* (2024) determined it as 22.96%. The protein content of mulberry leaves varies depending on fertilizer application, maturation period, cutting frequency, and climatic conditions (Bamikole *et al.*, 2005; Vu *et al.*, 2011).

In the study, the CF ratio was found to be 4.54% in mulberry leaves collected from Adana, while it was determined as 2.40% in mulberry leaves collected from Uşak. A statistical difference was detected among the provinces in terms of CF ratio. Ayaşan & Baylan (2016) reported the CF ratio of mulberry leaves as 5.57%, while Kandylis *et al.* (2009) determined it as 3.7%; Ustundag & Ozdogan (2023) as 5.5%; Hnokaew *et al.* (2024) as 1.65%; and Yan *et al.* (2024) as 4.37%.

The Acid Detergent Fiber (ADF), Neutral Detergent Fiber (NDF), Hemicellulose (HEM), and Organic matter digestibility (OMD) of mulberry leaves are given in Table 2.

In the study, the ADF ratio was found to be 28.44% in mulberry leaves collected from Aydın,

Table 2. ADF, NDF, hemicellulose, and organic matter digestibility contents of mulberry leaves used as study material

Province	ADF, % KM	NDF, % KM	HEM, % KM	OMD, %
Adana	20.22 ^e	28.97 ^{ef}	8.76 ^{cd}	51.39 ^b
Niğde	17.53 ^f	35.65 ^a	18.13 ^a	51.88 ^b
Sivas	23.68 ^c	33.63 ^{bc}	9.96 ^c	48.52 ^b
Nevşehir	17.64 ^f	29.38 ^{ef}	11.74 ^b	48.28 ^b
Uşak	20.40 ^e	28.61 ^{ef}	8.21 ^d	52.96 ^b
Yozgat	26.39 ^b	29.47 ^e	3.08 ^g	59.89 ^a
Adıyaman	24.36 ^c	32.01 ^d	7.66 ^{de}	46.13 ^b
Kayseri	21.91 ^d	28.45 ^f	6.55 ^{ef}	49.29 ^b
Aydın	28.44 ^a	34.10 ^b	5.65 ^f	52.20 ^b
Şanlıurfa	24.10 ^c	33.03 ^c	8.93 ^{cd}	49.55 ^b
S.H.	0.637	0.474	0.720	0.869
P	<0.001	<0.001	<0.001	0.017

P: Statistical significance level; S.H: Standard error of means. *Differences between means shown with different letters in the same column are statistically significant ($p < 0.05$).

while it was 17.53% in the Niğde group. The study showed that the ADF ratio was statistically significant ($P < 0.001$). Güven (2012) found similar results in a study conducted with mulberry leaves. In a study by Al-Kirshi *et al.* (2010), ADF ratios in mulberry leaves were determined to be between 28.00-35.00%. Sanchez (2000) reported an ADF ratio of 20.8-23.1%; Güven (2012), 17.33%; Kandyliş *et al.* (2009), 14.8%; Hnokaew *et al.* (2024), 13.26%; and Liu *et al.* (2025) found it to be between 29.6-52.6%. In the study, the lowest NDF ratio was found to be 28.45% in mulberry leaves collected from Kayseri, while it was 35.65% in mulberry leaves collected from Niğde. The NDF ratio was statistically significant ($P < 0.001$) in mulberry leaves collected from different provinces. In a study conducted by Al-Kirshi *et al.* (2010), NDF ratios in mulberry leaves were determined to be between 33.00-46.00%; Sanchez (2000) reported an NDF ratio of 24.6%; Butt *et al.* (2008), 27.6-43.3%; Güven (2012), 19.38%; Yu *et al.* (2018) reported the crude fiber ratio as 11.46-16.61%.

In the study, the HEM ratio was found to be 3.08% in the Yozgat group, while it was 18.13% in the Niğde group. The Niğde group had a higher HEM ratio. This difference was found to be statistically significant ($P < 0.001$). In a study, the HEM ratio of mulberry leaves was reported as 7.80% (Ayaşan & Baylan, 2016); Schmidek *et al.* (2000) determined it to be between 11.0-22.0%. Ali *et al.* (2023) reported

it as 10.02%.

In the study, the OMD ratio was found to be 46.13% in mulberry leaves collected from Adıyaman, while it was 59.89% in mulberry leaves collected from Yozgat. The difference between the provinces in terms of OMD ratio was found to be statistically significant ($P < 0.05$). In a study conducted by Güven (2012) on mulberry leaves, the OMD value ranged between 64.38-73.70%, with an average of 66.83%. A research study indicated that species and harvest time were important factors affecting the OMD value of mulberry leaves (Yao *et al.*, 2000). The OMD values obtained in our experiment were found to be lower than the OMD values (65.9-72.9%) reported by Yao *et al.* (2000). Other parameters related to mulberry leaves are presented in Table 3.

It was determined that the 24-hour GP values obtained from mulberry leaves varied between 23.33-40.33 ml, and the differences observed among mulberry leaves in terms of GP values were found to be statistically significant ($P = 0.014$). Among the feed materials used in the study, the highest 24-hour methane production percentage was found in the Yozgat group with 3.46 ml, while the lowest was detected in the Adıyaman group with 1.91 ml. The differences between groups were found to be statistically significant ($P < 0.05$).

The ME contents of mulberry leaves ranged between 6.94-9.07 MJ/kg DM, and a statistical differ-

Table 3. 24-hour in vitro gas and methane production. Metabolizable energy (ME) and net energy lactation (NEL) content of mulberry leaves when incubated in vitro with rumen buffered fluid

Province	24 h GP ml	24 h CH4 ml	ME, MJ/kg DM	NEL, MJ/kg DM
Adana	32.34 ^b	2.86 ^b	7.97 ^b	4.42 ^b
Niğde	31.67 ^b	2.59 ^b	7.77 ^b	4.47 ^b
Sivas	27.67 ^{bc}	2.31 ^{bc}	7.31 ^b	4.11 ^b
Nevşehir	29.34 ^{bc}	2.50 ^{bc}	7.14 ^b	4.05 ^b
Uşak	31.66 ^b	2.65 ^b	7.89 ^b	4.61 ^b
Yozgat	40.33 ^a	3.46 ^a	9.07 ^a	5.40 ^a
Adıyaman	23.33 ^c	1.91 ^c	6.94 ^b	3.80 ^b
Kayseri	31.00 ^{bc}	2.66 ^b	7.39 ^b	4.13 ^b
Aydın	31.60 ^b	2.78 ^b	7.79 ^b	4.51 ^b
Şanlıurfa	28.34 ^{bc}	2.48 ^{bc}	7.45 ^b	4.18 ^b
SEM	0.993	0.087	0.137	0.101
P	0.014	0.006	0.014	0.013

P: Statistical significance level; S.H: Standard error of means. *Differences between means shown with different letters in the same column are statistically significant ($p < 0.05$).

ence was detected in terms of mulberry leaves collected in the provinces ($P < 0.05$). The NEL contents of mulberry leaves varied between 3.80-5.40 MJ/kg DM, and a statistical difference was detected in terms of mulberry leaves collected in the provinces ($P < 0.05$). In a study conducted on this subject, the ME values of mulberry leaves ranged between 9.41-10.74 MJ/kg DM, and a statistical difference was found between the groups (Güven, 2012). Yao *et al.* (2000) stated that the factors affecting gas production kinetics were species and harvest time. Ustundag & Ozdogan (2023) determined that the ME value of mulberry leaf was 7.44 MJ/kg.

CONCLUSION

In conclusion, considering the deficit in our country's roughage production, it is possible to utilize the

obtained mulberry leaves and enhance their quality through various mixtures. The results obtained in this study have led to the conclusion that mulberry leaves, which often decay without being utilized, can be used as feed.

ACKNOWLEDGMENT AND/OR DISCLAIMERS, IF ANY

This article is based on the findings of the research financially supported by the Coordinator of Scientific Projects (BAP) of Erciyes University with project number FBA - 2022 - 11911.

CONFLICT OF INTEREST

The authors do not have any conflict of interest.

REFERENCES

- Ali, A., Tahir, H.M., Azizullah, S.A., Bhatti, M. F., Summer, M., & Gormani, A. H., 2023. Applications of mulberry leaves: An overview. *Punjab University Journal of Zoology*, 38(2), 137-152.
- Al-Kirshi, R.A., Alimon, A.R., Zulkifli, I., Sazili, A.O., Zahari, M.W., & Ivan, M., 2010. Utilization of mulberry leaf meal (*Morus alba*) as protein supplement in diets for laying hens. *Italian J Anim Sci*, 9(e51), 265-267.
- Antoine, F.R., Wei, C.I., Littell, R.C., & Marshall, M. R., 1999. HPLC method for analysis of free amino acids in fish using o-phthalaldehyde precolumn derivatization. *Journal of Agricultural and Food Chemistry*, 47, 5100-5107.
- AOAC., 1990. Association of Official Analytical Chemists. Official Methods of Analysis, 15th ed., Vol. 1. AOAC, Washington, DC, pp. 69-79.
- Aristoy, M.C., & Toldra, F., 1991. Deproteinization techniques for HPLC amino acid analysis in fresh pork muscle and dry-cured ham. *Journal of Agricultural and Food Chemistry*, 39, 1792- 1795.
- Ay, C., Ülger, İ., Kaliber, M., Hizlısoy, H., & Ayasan, T., 2023. Effects of Shiitake mushroom (*Lentinus edodes*) supplementation into quail diets on performance, blood serum parameters and intestine microbial populations: Effects of Shiitake Mushroom (*Lentinus edodes*) supplementations into quail diets. *Journal of the Hellenic Veterinary Medical Society*, 74(2), 5705-5712. <https://doi.org/10.12681/jhvms.30094>
- Ayasan, T., & Baylan, M., 2016. Kanatlı beslenmesinde dut yaprağının (*Morus alba*) kullanılması. *Turkish Journal of Agriculture-Food Science and Technology*, 4(6), 504-507.
- Ayaşan, T., Ülger, İ., Kaliber, M., Ergül, Ş., İnci, H., Mart, D., & Türkeri, M., 2018. Comparison of in vitro gas production, nutritive value, metabolizable energy and organic matter digestibility of some chickpea varieties. *Iranian Journal of Applied Animal Science*, 8(1), 131-136.
- Ayasan, T., Ülger, İ., Cil, A.N., Tufarelli, V., Laudadio, V., & Palangi, V., 2021. Estimation of chemical composition, in vitro gas production, metabolizable energy, net energy lactation values of different peanut varieties and line by Hohenheim in vitro gas production technique. *Semina: Ciências Agrárias*, 42(2), 907-920.
- Bamikole, M.A., Ikhatua, M.I., Ikhatua, U.J., Ezenwa, I.V., 2005. Nutritive value of mulberry (*Morus spp.*) leaves in the growing rabbits in Nigeria. *Pakist J Nutr*, 4(4), 231-236.
- Beyzi, S.B., Ülger, İ., & Koneca, Y., 2023. Chemical, fermentative, nutritive and anti-nutritive composition of common reed (*Phragmites australis*) plant and silage. *Waste and Biomass Valorization*, 14(3), 927-936. <https://doi.org/10.1007/s12649-022-01903-w>
- Butt, M.S., Nazir, A., Sultan, M.T., & Schoen, K., 2008. *Morus alba* L. Nature's functional tonic. *Trends in Food Science and Technology*, 19(10), 505-512.
- Chowdary, N.B., Rajan, M.V., & Dandin, S.B., 2009. Effect of poultry feed supplemented with mulberry leaf powder on growth and development of broilers. *The IUP J Life Sci*, 111(3), 51-54.
- Cui, Y., Liu, Z., Deng, D., Tian, Z., Song, M., Lu, Y., ... & Ma, X., 2024. Influence of fermented mulberry leaves as an alternative animal feed source on product performance and gut microbiome in pigs. *Fermentation*, 10(4), 215.
- Djilani, A. Legseir, B., Soulimani, R., Dickob, A., & Younos, C., 2006. New extraction technique for alkaloids. *J. Braz. Chem. Soc.*, 17(3), 518-520.
- Ekizoğlu, H., Ülger, İ., Kaliber, M., & Ayaşan, T. 2020. Effects of spirulina (algae) supplementation to Japanese Quail (*Coturnix coturnix Japonica*) diets on growth performance and carcass traits. *Indian Journal of Animal Sciences*, 9(6), 923-927.
- Fritsche, J., & Steinhart, H. 1998. Amounts of conjugated linoleic acid (CLA) in German foods and evaluation of daily intake. *Zeitschrift für Lebensmitteluntersuchung und-Forschung A*, 206(2), 77- 82.
- Geng, B., Gao, J., Cheng, H., Guo, G., & Wang, Z., 2024. Effects of dietary mulberry leaves on growth, production performance, gut microbiota, and immunological parameters in poultry and livestock: a systematic review and meta-analysis. *Animal Bioscience*, 37(6), 1065.
- Goering, H.K., & Van Soest, P.J., 1975. Forage fiber analysis (Apparatus, Reagents, Procedures and Some Applications). *Agricultural Hand-Book No:379*, Washington, D.C.,
- Guo, L., Shi, X., Cao, F., Hu, S., & Qian, W. (2025). Effects of dietary addition of mulberry leaf powder on blood metabolites and fecal microbiota composition in Hu sheep. *Frontiers in Animal Science*, 5, 1469850.
- Güven, I., 2012. Effect of species on nutritive value of mulberry leaves. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 18(5), 865-869.
- Hnokaew, P., Sringarm, K., Chuammitri, P., Arjin, C., Lumsangkul, C., Mekchay, S., ... & Vinitchaikul, P., 2024. Influence of dietary mulberry (*Morus alba* L.) leaf supplementation on production performance, blood metabolites, rumen fermentation characteristics and ruminal bacteria community in lactating dairy cows. *Italian Journal of Animal Science*, 23(1), 1031-1043.
- İşbilir, Ş.S., & Çelik, E., 2021. Edirne ilinde yetişen dut ağacı yapraklarının antioksidan ve anti diyabetik aktivitesi üzerine bir çalışma. *Journal of Advanced Research in Natural and Applied Sciences*, 7(3), 319-332.
- Kandylis, K., Hadjigeorgiou, I., & Harizanis, P., 2009. The nutritive value of mulberry leaves (*Morus alba*) as a feed supplement for sheep. *Tropical Animal Health and Production*, 41, 17-24.
- Krol, E., Jeszka-Skowron, M., Krejpcio, Z., Flaczyk, E., & Wojciak, R.W., 2016. The effects of supplementary mulberry leaf (*Morus alba*) extracts on the trace element status (Fe, Zn and Cu) in relation to diabetes management and antioxidant indices in diabetic rats. *Biological Trace Element Research* 174, 158-165.
- Liu, Q., Zhuo, Z., Zhang, J., Chen, G., Xu, D., Wang, X., & Ali, H., 2025. Nutritional quality assessment of mulberry leaves from different varieties as an alternative feed in ruminant nutrition. *Journal of Food Composition and Analysis*, 107213.
- López, S., Makkar, H. P., & Soliva, C. R., 2010. Screening plants and plant products for methane inhibitors. In *In vitro screening of plant resources for extra-nutritional attributes in ruminants: nuclear and related methodologies* (pp. 191-231). Springer Netherlands.
- Menke, K. H., Raab, L., Salewski, A., Steingass, H., Fritz, D., & Schneider, W., 1979. The estimation of the digestibility and metabolizable energy content of ruminant feedingstuffs from the gas production when they are incubated with rumen liquor in vitro. *J. agric. Sci.*, 93, 217- 222.
- Menke, K.H., & Steingass, H., 1988. Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. *Animal Research and Development*, 28, 7-55.
- Mertens, D., 2005. AOAC Official Method 975.03. Metal in Plants and Pet Foods. *Official Methods of Analysis*, 18th edn. Horwitz, W, and G.W. Latimer, (Eds). Chapter 3, pp. 3- 4,
- Nickel, J., Spanier, P.L., Botelho, F.M., Gularte, M.A., & Helbig, E., 2016. Effect of different types of processing on the total phenolic compound content, antioxidant capacity, and saponin content of *Chenopodium quinoa* Willd grains. *Food Chemistry*, 209, 139-143.
- Ørskov, E.R., & McDonald, P., 1979. The estimation of protein degradability in the Rumen from incubation measurements weighed according to rate of passage. *J. Agric. Sci.*, 92, 499- 503.
- Phiny, C., Preston, T.R., Ly, J., 2003. Mulberry (*Morus alba*) leaves as protein source for young pigs fed rice-based diets: Digestibility studies; LRRD, (15) 1. Retrieved February 29, 2012, from <http://www.lrrd.org/lrrd15/1/phin151.htm>, 2003.
- Sanchez, M.D., 2000. Mulberry: An exceptional forage available almost worldwide. *World Animal Review*. 93, 1-21, FAO, Rome.
- Sarkhel, S., Manvi, D., & Ramachandra, C.T., 2020. Nutrition importance and health benefits of mulberry leaf extract: A review. *Journal of Pharmacognosy and Phytochemistry*, 9(5), 689-695.
- Schmidek, A., Takahashi, R., de Medeiros, A.N., & de Resende, K.T., 2000. Bromatological composition and degradation rate of mulberry in goats. In: Sanchez (ed), "Mulberry for Animal Production". <http://www.fao.org/ag/AGA/AGAP/FRG/Mulberry/Posters/PDF/Schmidk1.pdf>

- Todaro, M., Sinacori, A., Marinaro, G., Alicata, M.L., Giaccone, P., 2007. Palatability and in vivo digestibility of Mulberry leaves (*Morus latifolia* CV. Kokusou 21) in sheep feeding. *JAVA*, 6, 509-512.
- Ustundag, A. M., & Ozdogan, M., 2023. Effects of mulberry leaves on growth performance, carcass characteristics, and meat quality of Japanese quail. *South African Journal of Animal Science*, 53(1), 82-90.
- Ülger, I., Kamalak, A., Kurt, O., Kaya, E., & Guven, I., 2017. Comparison of the chemical composition and anti-methanogenic potential of *Liquidambar orientalis* leaves with *Laurus nobilis* and *Eucalyptus globulus* leaves using an in vitro gas production technique. *Cien Inv Agr: Rev Latin de Cien Agr*, 44(1), 75-82. <http://dx.doi.org/10.7764/rcia.v44i1.1637>
- Ülger, İ., Kaliber, M., Beyzi, S. B., Konca, Y., 2020. Possible ensiling of pumpkin (*Cucurbita pepo*) residues. *Turkish Journal of Veterinary & Animal Sciences*, 44(4), 853-859. <https://doi.org/10.3906/vet-2002-81>
- Ülger, İ., Kaliber, M., Hizlisoy, H., & Ayasan, T., 2023. Effects of reishi mushroom (*ganoderma lucidum*) powder inclusion into quail diets on animal performance, carcass traits, intestinal microflora and serum parameters. *Journal of the Hellenic Veterinary Medical Society*, 74(2), 5829–5836. <https://doi.org/10.12681/jhvms.30440>
- Vu, C.C., Verstegen, M.W.A., Hendriks, W.H., & Pham, K.C., 2011. The nutritive value of mulberry leaves (*Morus alba*) and partial replacement of cotton seed in rations on the performance of growing Vietnamese cattle. *Asian-Aust J Anim Sci*, 24(9), 1233-1242.
- Van Soest, P.J., Robertson, J.B., & Lewis, B.A., 1991. Methods for dietary fiber, neutraldetergent fiber and nonstarch polysaccharides in relation to animal nutrition. *J. Dairy Sci.*, 74, 3583-3597.
- Yan, C.H., Chen, F.H., Yang, Y.L., Shen, L.W., Xun, X.M., Zhang, Z.A., ... & Wang, J., 2024. Biochemical and protein nutritional potential of mulberry (*Morus alba* L.) leaf: partial substitution improves the nutrition of conventional protein. *Journal of the Science of Food and Agriculture*, 104(4), 2204-2214.
- Yao, J., Yan, B., Wang, Q., & Liu, J.X., 2000. Nutritional evaluation of mulberry leaves as feeds for ruminants. *LRRD*, 12(2), 2000, <http://www.cipav.org.co/lrrd/lrrd12/2/yao122.htm>. Accessed: 27.02.2012.
- Yu, Y., Li, H., Zhang, B., Wang, J., Shi, X., Huang, J., ... & Deng, Z., 2018. Nutritional and functional components of mulberry leaves from different varieties: Evaluation of their potential as food materials. *International Journal of Food Properties*, 21(1), 1495-1507.