JOURNAL of AGRICULTURE

RESEARCH ARTICLE ISSN: 2636-8757

Evaluation of Fruit Residues as a Feed Material Based on Nutrient Content and Gas Production

Emrah KAYA[1]* | **Adem KAMALAK[2]**

[1]Iğdır University, Faculty of Agriculture, Department of Animal Science, Iğdır, Turkey

[2]Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Department of Animal Science, Kahramanmaras, Turkey

Correspondence
Emrah KAYA, Iğdır University, Faculty of Agriculture, Department of Animal Science, Iğdır, Turkey.
Email:
emrah.kaya@igdir.edu.tr

This study was produced from EK's PhD thesis.

The study does not require ethics committee approval.

Abstract

In this study, it was aimed to evaluate the nutrient content, gas production, methane production, metabolisable energy, and organic matter digestibility of some fruit residues obtained from markets. Lemon, orange, tangerine, apple, melon, watermelon, pomegranate, and pear were used as study materials. On the collected materials, crude ash (CA), dry matter (DM), acid detergent fiber (ADF), neutral detergent fiber (NDF), ether extract (EE), and crude protein (CP) analysis were performed; gas production (GP) values were found; and metabolic energy (ME) contents and organic matter digestibility (OMD) degrees of residues were calculated depending on these values. The species significantly ($P<0.001$) affected the nutrient content and GP values of residues. The CA, DM, ADF, NDF, EE, and CP of fruit residues varied between 0.44 and 0.99%, 6.81 and 25.65%, 5.02 and 16.75%, 8.15 and 21.04%, 3.32 and 12.55%, and 1.81 and 10.89%, respectively. The GP, net methane, percentage of methane, ME, and OMD of residues varied between 61.22 and 90.95 ml, 6.93 to 11.04 ml, 10.96 to 12.92%, 10.91 to 14.92 mj kg^{-1} DM, and 72.62 to 98.96%, respectively. Based on the findings obtained as a result of the study, it is understood that these residues can be a good feed source for ruminant animals, but it is thought that studies on the use of these water-rich residues by both the drying method and silage with other feed materials should continue. Considering its anti-methanogenic properties, pomegranate residues were close to this potential but were not found at the desired level. By using these residues, which are seen as garbage, in animal nutrition, environmental pollution will be prevented.

Key words: Fruit residues, gas production, market wastes, nutrient content

INTRODUCTION

As it is known, despite the rising animal production potential in our country, which has a developed livestock organization, the most important issue that still poses a problem is the inability to meet the need for quality and cheap roughage. Accordingly, 60-65% of the production expenses of livestock enterprises are composed of feed expenses (Kılıç, 1986).

In order to increase the profitability of production in the enterprise, the input costs should be minimized, but the production quality should not be compromised. The first step in reducing the cost of production inputs will be to reduce the cost of roughage. In this context, producers are developing various methods and looking for new solutions in the supply of roughage. In many studies on animal nutrition in our country for many years, it has been mentioned that insufficient feed resources and animal husbandry cannot reach the desired level. However, it is emphasized on every platform that ruminant animal feeding constitutes the biggest and most important problem (Filya, 2001). The fact that the production quantities and product quality of feed raw materials are low, but the prices are

Received: 11.05.2022 | Accepted: 01.06.2022

more expensive than they should be, is also specified in the study conducted by Özdüven et al. (2005). Among these solutions, it will be preferable to meet the roughage with the lowest input cost. When these predictions are taken into consideration, it is understood that the main source should consist of residual material, that is, surplus material released as a result of any process. The main source of residual feed resources is the neighborhood markets and fruit and vegetable markets, where marketing processes are carried out to be offered for human consumption. The main reason for the production of vegetables and fruits is their position in human nutrition. However, in cases where the desired conditions are not met during production and consumption; the products that are left under the factors such as abundant production and prices not being at the desired level can turn into an alternative product that can be used in other areas by passing into the non-use position called waste. Although the leftover vegetable and fruit mixtures left over from the district markets and fruit and vegetable markets can be used as an alternative source of forage, it has been reported by Vural (2000) that the amount of residual product released is between 7-10 million tons per year. According to Turkish Statistical Institute, the total amount of fruit and vegetables produced in our country as of 2014 was stated as over 45 million tons, and nearly 28 million tons of the total production consisted of vegetable production and 17 million tons of fruit production (TUIK, 2015).

In this context, this study was carried out to determine the nutritional potential of fruit residues in terms of animal nutrition, which is an important branch of organic wastes released as a result of the marketing of herbal products, which is one of the elements that provide the necessary nutritional factors for people to continue their vital activities. In this study, it was aimed to evaluate the nutrient content of fruit residues left over from markets and the anti-methanogenic characteristics of these products.

MATERIALS and METHODS

The residual materials used in the research were determined to include eight samples from fruit residues, taking into account the production, seasonal and regional conditions. Lemon, orange, tangerine, apple, melon, watermelon, pomegranate, and pear were chosen to be used in the study. The determined residual materials were obtained from the markets established on certain days in the Onikişubat district of Kahramanmaraş province. The supplied study materials were brought to the Animal Feed and Animal Nutrition Laboratory in Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Animal Science, and were taken to the preparation stage for chemical composition and other analyses.

The study samples collected from the district markets of Kahramanmaraş were purified from mud and similar residues in the laboratory. Then, it was chopped finely with the help of knives and made ready for the drying process for analyses other than dry matter and raw ash analyses. The chopped samples were laid on blotting papers and left to dry at room temperature. The drying process lasted for about 7 days, and the samples were mixed and laid again until it was observed that the water contained in them completely evaporated. Following the completion of the drying process, the samples were homogeneously ground to pass through a 1 mm sieve with the help of a grinding mill and made ready for chemical analysis. The DM, CA, EE, and CP contents of the residues were determined according to the method reported by AOAC (1990). ADF and NDF contents were determined by Van Soest et al. (1991) according to the method reported. Fruit residues were subjected to fermentation as described in the *in vitro* gas production method by Menke et al. (1979). Rumen content was obtained from slaughtering two adult cattle at the slaughterhouse in Kahramanmaraş. An infrared methane analyzer (Sensor Europe, Germany) is used to measure the CH_4 (percentage) of the gas (Goel et al., 2008).

The methane production of fruit residues per mL was calculated by the following equation;

$$CH_4 \text{ production (ml)} = \text{Total gas production (ml) X Percentage of } CH_4 \text{ (\%)}$$

Menke and Steingass (1988) equations were used to calculate the ME and OMD of fruit residues;

$$ME \text{ (mj kg}^{-1} \text{ DM)} = 2.20 + 0.1357\, GP + 0.057\, CP + 0.002859\, EE^2 \qquad \text{(I)}$$

$$OMD \text{ (\%)} = 15.38 + 0.8453\, GP + 0.595\, CP + 0.675\, CA \qquad \text{(II)}$$

The obtained data were analyzed using SPSS 17.0 (2011), and the differences between the means were determined using Tukey multiple comparison tests.

RESULTS and DISCUSSION

Nutrient Content of Fruit Residues

The nutrient content of fruit residues is given in Table 1. The species significantly ($P<0.001$) affected the CA, DM, ADF, NDF, EE, and CP of fruit residues. The CA of fruit residues ranged between 0.44 and 0.99%, with the lowest value being found in orange and the highest in pomegranate residues. The DM of fruit residues ranged between 6.81 and 25.65%, with the lowest being found in melon and the highest in pomegranate residues. In terms of ADF and NDF contents, the lowest rate was found in apple and the highest in melon, with 5.02 and 8.15%, 16.75 and 21.04%, respectively. Pear had the lowest EE content at 3.32%, while lemon had the highest at 12.55%. When the CP content was compared on the basis of DM, the CP content of pear was 1.81%, while that of watermelon was 10.89%.

Table 1. Nutrient content of fruit residues

	CA (%)	DM (%)	ADF (%)	NDF (%)	EE (%)	CP (%)
Lemon	0.71^{b}	22.80^{b}	13.62^{b}	18.37^{b}	12.55^{a}	7.74^{c}
Orange	0.44^{c}	18.43^{d}	7.27^{d}	11.18^{e}	3.65^{de}	6.99^{d}
Tangerine	0.76^{b}	20.57^{c}	7.69^{d}	11.22^{e}	3.57^{de}	6.01^{e}
Apple	0.45^{c}	19.14^{cd}	5.02^{e}	8.15^{f}	4.41^{cd}	2.34^{f}
Melon	0.54^{c}	6.81^{e}	16.75^{a}	21.04^{a}	6.70^{b}	9.30^{b}
Watermelon	0.54^{c}	7.00^{e}	10.45^{c}	14.45^{d}	4.20^{de}	10.89^{a}
Pomegranate	0.99^{a}	25.65^{a}	9.25^{c}	16.87^{c}	5.22^{c}	5.90^{e}
Pear	0.45^{c}	18.71^{d}	12.53^{b}	18.66^{b}	3.32^{e}	1.81^{g}
SEM	0.047	0.502	0.370	0.326	0.278	0.146
Sig.	***	***	***	***	***	***

[abc] Column means with common superscripts do not differ. CA: Crude ash (% of DM), DM: Dry matter (%), ADF: Acid detergent fiber (% of DM), NDF: Neutral detergent fiber (% of DM), EE: Ether extract (% of DM), CP: Crude protein (% of DM), SEM: standard error mean, Sig: Significant level, ***: P<0.001.

In the study, Karaçalı (2004), found the DM values of apple, pear, melon, watermelon, pomegranate, orange, tangerine, and lemon between 8-15%, CP content between 0.3-1.0% and EE content between 0.1-0.6%. The values found and the results of the study do not show any similarity, and the reported values are quite low compared to the results of the current study. In a study investigating the use of orange in terms of animal nutrition, Filya (2001) found the DM content at

13%. The reported value is lower than the value found in the current study. In the study of Marino et al. (2010), they found the results that the apples have 13.4% DM, 7.46% NDF, 0.75% CP and 0.14% EE; tangerines have 10.7% DM, 9.25% NDF, 6.45% CP and 0.35% EE; oranges have 14.1% DM, 8.44% NDF, 4.96% CP and 0.26% EE; 9.7% DM, 8.25% NDF, 15.7% CP and 0.15% EE of melon; and 11.8% DM, 19.41% NDF, 3.64% CP and 0.11% EE of pear. The NDF contents of apple and pear and the CP contents of tangerine were similar between the reported values and the results of the current study. The DM and EE contents of melon were higher in the reported values, while other values were higher in the current study.

Gas Production, Methane Content, Metabolic Energy and Organic Matter Digestibility of Fruit Residues

Gas production, methane content, ME, and OMD of fruit residues are given in Table 2. The species significantly ($P<0.001$) affected the GP, methane content, ME, and OMD of fruit residues. The net gas production values of fruit residues ranged between 61.22 and 90.95 ml (200 mg kg^{-1} DM), with the highest gas production being found in tangerine and the lowest in pomegranate residues. The methane gas production values of fruit residues ranged between 6.93 and 11.04 ml (200mg kg^{-1} DM), with the highest methane production being found in orange and the lowest in pomegranate residues. In terms of CH_4 content, the lowest rate was found in pomegranates with 10.96%, while the highest rate was found in pears with 12.92%. The ME content of pomegranate was lowest with 10.91 mj kg^{-1} DM, while that of tangerine was found to be highest with 14.92 mj kg^{-1} DM. While the OMD of pomegranate was 72.62%, it was found to be 98.96% of tangerine.

Table 2. Gas production, methane content, metabolic energy and organic matter digestibility of fruit residues

	Net Gas (ml)	CH_4 (ml)	CH_4 (%)	ME (mj kg^{-1} DM)	OMD (%)
Lemon	85.70^{b}	9.99^{bc}	11.66^{bc}	14.68^{ab}	95.02^{ab}
Orange	88.95^{ab}	11.04^{a}	12.41^{ab}	14.70^{a}	97.41^{a}
Tangerine	90.95^{a}	10.87^{ab}	11.96^{abc}	14.92^{a}	98.96^{a}
Apple	85.58^{b}	10.23^{abc}	11.96^{abc}	14.00^{bc}	92.33^{bc}
Melon	73.23^{c}	8.32^{e}	11.38^{bc}	12.78^{de}	84.52^{d}
Watermelon	77.57^{c}	9.00^{de}	11.61^{bc}	13.39^{cd}	89.09^{c}
Pomegranate	61.22^{e}	6.93^{f}	10.96^{c}	10.91^{f}	72.62^{e}
Pear	76.36^{c}	9.86^{cd}	12.92^{a}	12.69^{e}	83.89^{d}
SEM	1.420	0.282	0.337	0.201	1.302
Sig.	***	***	***	***	***

^{abc} Column means with common superscripts do not differ. CH_4: Methane (%), ME: Metabolisable Energy (mj kg^{-1} DM), OMD: Organic Matter Digestibility (%), SEM: Standard Error Mean, Sig: Significant level, ***: $P<0.001$

According to Marino et al. (2010), apple has 7.1 ME, 52.3% OMD, 39.4 ml gas production, tangerine has 9.6 ME, 68.8% OMD, 53.4 ml gas production, orange has 11.3 ME, 79.7% OMD, 65.5 ml gas production, melon has 8.3 ME, 83.8% OMD, 40.9 ml gas production, and pear has 5.7 ME, 47% OMD. No similarity was observed between the reported values and the results of the current study, and all values were higher in the present study.

According to the method determined by Lopez et al., (2010) of methane gas values formed in feeds, low anti-mehanogenic (>11% and 14%), medium anti-metanogenic (> 6% and 11%) and high anti-methanogenic (> 0% and 6%) are possible to classify. By taking these classifications into consideration, the energy use efficiency of ruminants can be increased and the methane gas that causes global warming can be reduced. The data obtained as a result of the study shows that pomegranate residues are in the medium anti-methanogenic class. Other fruit residues are in the low anti-methanogenic class, and their contribution to the prevention of global warming is thought to be limited.

CONCLUSION

This study was carried out to determine the nutritional values and anti-methanogenic properties of some fruit residues obtained from markets. The chemical differences of the waste materials used in the study significantly affected the *in vitro* gas production values, methane gas contents, and metabolic energy calculated based on the results of these values, as well as the organic matter digestion degrees of these residues. Based on the findings obtained as a result of the study, it is understood that these residues can be a good feed source for ruminant animals, but it is thought that studies on the use of these water-rich residues by both the drying method and silage with other feed materials should continue. The effective and efficient use of fruit residues will also reduce the cost of animal feeding. Reducing this cost will result in an increase in the income of the farmers and, consequently, the prevention of waste as well as the management and reduction of environmental pollution. As a result, bringing this alternative source to animal husbandry in an organized manner is an important issue for the country's economy, our future, and each element of animal production. Diversifying and increasing the scope of this and similar studies will be beneficial for our country and livestock.

ACKNOWLEDGEMENTS

This study was produced from EK's PhD thesis.

AUTHOR CONTRIBUTIONS

The authors have contributed equally to this study.

CONFLICT of INTEREST

The authors declare there is no conflict of interest.

REFERENCES

AOAC. (1990). Official method of analysis. 15th ed., Association of Official Analytical Chemists, Washington, DC, USA. pp.66-88.

Filya, İ. (2001). Silaj teknolojisi. U.Ü.Z.F. Zootekni B., Görükle - Bursa, Hakan ofset - İzmir.

Goel, G., Makkar, H.P.S., & Becker, K. (2008). Effect of sesbania sesban and carduus pycnocephalus leaves and fenugreek (Trigonella foenum-graecum L) seeds and their extract on partitioning of nutrients from roughage-and concentrate-based feeds to methane. Animal Feed Science and Technology, 147(1-3), 72-89.

Karaçalı, İ. (2004). Bahçe Ürünlerinin Muhafaza ve Pazarlanması, E.Ü.Z.F.Yayınları No:494. E.Ü. Basımevi, Bornova - İzmir.

Kılıç, A. (1986). Silo yemi. Bilgehan Basımevi. Bornova - İzmir.

Lopez, S., Makkar, H.P.S., & Soliva, C.R. (2010). Screening plants and plant products for methane inhibitors. In: Vercoe PE, Makkar HPS, Schlink A, (Eds): *In vitro* screening of plant resources for extra nutritional attributes in ruminants: Nuclear and related methodologies. London, New York, pp. 191- 231.

Marino, T.C., Hector, B., Rodrigues, P.H.M., Borgatti, L.M.O., Meyer, P.M., Silva, E.J.A., & Orskov, E.R. (2010). Characterization of vegetables and fruits potential as ruminant feed by *in vitro* gas production technique. Livestock Research for Rural Development. 22, 1–9.

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*. Journal of Agricultural Science, 93, 217-222.

Menke, K.H., & Steingass, H. (1988). Estimation of energetic feed value obtained from chemical analysis and *in vitro* gas production. Animal Research Development, 28, 7-55.

Özdüven, M.L., Coşkuntuna, L., & Koç, F. (2005). Üzüm posası silajının fermantasyon ve yem değeri özelliklerinin saptanması. Trakya Üniversitesi Fen Bilimleri Dergisi, 6(1), 45-50.

SPSS, (2011). IBM SPSS statistics for Windows, version 17.0. New York: IBM Corp 440.

TUİK. (2015). Türkiye İstatistik Kurumu, Bitkisel ürün denge tabloları. https://biruni.tuik.gov.tr/medas/?kn=104&locale=tr

Van Soest, P.V., Robertson, J.B., & Lewis, B.A. (1991). Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74(10), 3583- 3597.

Vural, H., Eşiyok, D., & Duman, İ. (2000). Kültür sebzeleri (Sebze yetiştirme), Ege Üniversitesi Basımevi Bornova, ss: 253-260.