DR-2284
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RESEARCH ARTICLE Asian Journal of Dairy and Food Research

Assessing the Nutritional Content of Grape Pomace and its Potential Utilization as a Fruit Processing Industry Waste: A Substitute for Livestock Feed

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10.18805/ajdfr.DR-2284

ABSTRACT

Background: The use of unconventional feeds is being increased nowadays due to lack of feeds and fodders for livestock especially during scarcity period. Grape pomace, a leftover product from the fruit processing industry waste can be considered as an alternative to conventional feed ingredients. A study was carried out to investigate the potential of Grape pomace as an alternative feed resource for livestock.

Methods: Grape pomace samples were collected and analysed for its proximate composition, fibre fractionations, calcium, phosphorus, total tannin, total gas production, *in vitro* dry matter degradability and methane.

Result: The per cent dry matter, crude protein, crude fibre, ether extract, total ash and nitrogen free extract were found to be 79.60, 13.17, 55.28, 12.89, 2.68 and 15.98 respectively. The per cent calcium and phosphorus were 0.50 and 0.31 respectively. Fibre fractions of the per cent NDF, ADF and non-fibrous carbohydrates were 55.24, 52.88 and 16.02 respectively. The *in vitro* dry matter degradability, organic matter digestibility and metabolizable energy were 19.29, 56.33 per cent and 7.93 MJ/Kg respectively. The short-chain fatty acids and net energy for lactation were calculated to be 8.43 mmol and 4.25 MJ/Kg respectively. The total tannin content was found to be 4.67 per cent. The total methane production by Grape pomace was 12.42 per cent. The results reveal that Grape pomace, valuable fruit industry waste can be used as an alternative feed resource for livestock feeding.

Key words: Grape pomace, *In vitro* dry matter degradability, Metabolizable energy, Organic matter digestibility.

INTRODUCTION

An increase in livestock, human population, the decline in land under cultivation and natural disasters like floods and droughts has resulted in severe shortage of feeds and fodder for livestock. Hence, to meet the nutrient requirement of livestock and to sustain their productivity, non-conventional alternate feed resources are utilised to bridge the gap between demand and supply of nutrients, thereby to economise livestock farming (Massod Danish *et al.,* 2018). One such non-conventional feeds used in livestock feeding is the fruit industry waste which are obtained from the processing industries. Lot of studies have been done on the usage of pomace (residue left after extraction of juice from the fruit) eg. Apple pomace, which is used as a traditional animal feed ingredient (Kengoo *et al.,* 2023).

India is an agricultural country with a total production of 112.73 million metric tonnes of fruits and 205.80 million metric tonnes of vegetables in 2023-24 (3rd Advance estimate, National Horticulture Board). Grape is the commercial fruit crop of the peninsular part of India that is a member of the Vitaceae family. Among the major producers of Grapes in the world like China, France, Spain, Italy and USA, India ranks 5th among the top 10 grape-producing countries of the world. India produces about 3911 thousand metric tonnes of grapes covering an area of 175.93 thousand hectares which is majorly contributed from Maharashtra, Karnataka and Tamil Nadu. At the state level, Tamil Nadu ranks third in grape production next to Maharashtra and Karnataka with a total production of 50.73 thousand tonnes in an area of 2 thousand hectares. (2023 -24, 3rd Advance Estimate, National Horticulture Board). In Tamil Nadu, grape production is highest in the Theni district followed by Coimbatore and Dindigul. Theni Cumbum

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How to cite this article: Subhashini, J., Arulnathan, N., Thirumalaisamy, G. and Jagatheesan, P.N.R. (2025). Assessing the Nutritional Content of Grape Pomace and its Potential Utilization as a Fruit Processing Industry Waste: A Substitute for Livestock Feed. Asian Journal of Dairy and Food Research. 1-7. doi: 10.18805/ajdfr.DR-2284.

Submitted: 22-10-2024 **Accepted:** 03-03-2025 **Online:** 19-04-2025

Muscat Hamburg grapes (Paneer thiratchai), a variety of grapes has recently earned the Geographical Indication (GI) tag for its cultivation throughout the year.

Grapes are sold to wholesalers or retail outlets for human consumption and from the bulk production, grapes are sent to the fruit processing industries. The main constraint faced by the fruit industries is the disposal of the wastes that are produced after the extraction of juice. Grape pomace is the leftover waste from grapes that includes the seeds, stems, skin and the remaining pulp after extraction of juice from Grapes, accounting about 55 to 65 per cent of the fruit. It has been roughly estimated that the leftover of grape fruit processing industry was 2.2 T/ha/year (Gurumeenakshi *et al.,* 2021). The nutritional value and chemical composition of grape pomace depend on grape varieties, production, different processing methods and the relative ratio of components of pomace (Basalan *et al.,* 2011).

The price of conventional feed ingredients are very much high and finding an alternative with nutritive value without affecting the production performance of the livestock is the need of hour. Since a large amount of grape pomace has been wasted/unutilized or used as manure, the present study has been planned to analyse the chemical composition of grape pomace and its digestibility to explore its possibilities as a replacer for conventional feed ingredients.

MATERIALS AND METHODS

Sample collection

Grape pomace samples were collected from a private fruit processing industry at Theni district. The samples were collected during the period from September to December in the year 2023. The private fruit processing industry collects different varieties of grapes from different regions of Theni district and uses them for processing.

Proximate analysis

The collected samples were dried in hot air oven, ground and analysed for its proximate composition and the major mineral composition as per AOAC (2000). All the nutrients were expressed as a percentage of dry matter. The grape pomace fibre fractionations were carried out to determine the per cent NDF and ADF as per Van Soest *et al.* (1963). The non-fibrous carbohydrate was calculated by using the equation defined by NRC (2001) as mentioned below: (NRC, 2001)

$$\text{NFC (\%)} = [100-(\%\text{NDF}+\%\text{CP}+\%\text{EE}+\%\text{Total Ash}]$$

Tannin estimation

The total tannin content of the Grape pomace was estimated using the volumetric method (Sastry *et al.,* 1999). About 5 g of dried, powdered, fat-free sample was taken in a 1000 ml beaker and the sample was refluxed in 300 ml distilled water for 1 hour. The filtrate was collected by decantation. Subsequently, the residue was again refluxed with another 200 ml of distilled water for 15 minutes. Thereafter, filtrate was collected, cooled and made volume up to 500 ml and filtered using Whatman Filter Paper No.1. Total tannin content was estimated by titration method against 0.1 N $KMnO_4$ with blank and the sample. In blank, about 101 ml of distilled water was taken and 2 ml of indigo carmine solution was added and titrated against 0.1 N potassium permanganate solution. The volume of 0.1 N $KMnO_4$ used was recorded as V_0 (Blank).

In sample, about 1 ml of aliquot from the sample was taken and 100 ml of distilled water and 2 ml of indigo carmine solution were added. Then the sample was titrated against 0.1 N $KMnO_4$ and the volume used was recorded as V. The total tannin present in the sample was calculated using the formula given below.

$$\text{Tannic acid (on DM basis)} = \frac{(V-V_0)\times 0.006235 \times 500 \times 100}{\text{Sample weight}}$$

Where,

V = Volume of 0.1 N $KMnO_4$ used in sample.
V_0 = Volume of 0.1 N $KMnO_4$ used in blank.
W = Dried weight of sample.

In vitro analysis

Samples were analysed for the *in vitro* dry matter degradability using *in vitro* gas production technique as per Menke and Steingass (1988). The digestible organic matter (DOM) and metabolizable energy (ME) content of Grape pomace were calculated using the prediction equation adopted by Menke *et al.,* (1979). The short-chain fatty acids (SCFA) and the net energy for lactation (NE_L) were calculated using the equation given by Makkar (2005) and Abas *et al.* (2005) respectively.

$$\text{DOM (\%)} = 14.88 + 0.889 \times GP + 0.45 \times CP + 0.65 \times TA$$

$$\text{ME (MJ/Kg DM)} = 2.20 + 0.136 \times GP + 0.0057 \times CP + 0.0029 \times EE2$$

$$\text{SCFA (mmol)} = 0.0222GP - 0.00425$$

$$NE_L \text{ (MJ/kg DM)} = 0.115 \times GP + 0.0054 \times CP + 0.014 \times EE - 0.0054 \times TA - 0.36$$

Where

GP = Total gas production at 24 hours (ml/200 mg DM).
CP = Crude protein.
EE = Ether extract.
TA = Total ash.

Methane estimation

The amount of methane produced was measured using displacement method as described by Nganyira *et al.* (2023).

RESULTS AND DISCUSSION

Nutrient composition of grape pomace

The per cent proximate composition, major mineral composition, Vansoest fibre fractions, total tannin content of grape pomace collected from fruit processing industry is given in Table 1.

The mean CP and EE in the current study were higher than those reported by Zhao *et al.* (2018); Runjan

Duworaha *et al.* (2018); Vinyard *et al.* (2021); Juracek *et al.* (2021); Suescun-Ospina *et al.* (2022); Kara and Oztas (2023) whereas lower than those reported by Wang *et al.* (2020) who observed higher CP and EE compared to the present study.

The mean CF was higher than those reported by Pop *et al.,* (2015) and Wang *et al.* (2020). Similarly, the mean NDF and ADF in the current study were higher than the previous researchers (Bahrami *et al.,* 2010; Zhoa *et al.,* 2018; Runjan Duworaha *et al.,* 2018; Vinyard *et al.,* 2021; Juracek *et al.,* 2021; Suescun-Ospina *et al.,* 2022). However, Kara and Oztas (2023) reported higher NDF and lower ADF than the current study. The mean Calcium in the present study was lower but Phosphorus content was found to be higher than the findings of Zhoa *et al.* (2018) and Spinei and Oroian, (2021).

A lot of variations in the nutrient composition of grape pomace have been observed by different scientists. The variation in the nutrient composition of grape pomace with the present results may be due to the variation in the grapes variety, area of cultivation, climatic conditions, growing conditions of the grapes, fruit maturity, post harvesting management (Maheri-Sis *et al.,* 2008), different processing conditions (Deng *et al.,* 2011; Foiklang *et al.,* 2016) in different fruit processing and wine industries. The relative ratio of components of Grape pomace (seeds, stem, skin) which would differ based on the different processing conditions may also cause variation in the nutrient composition of grape pomace.

Tannin content

Tannins are nutritionally important plant secondary compounds that are the second most abundant group of plant phenolics after lignin (Animut *et al.,* 2008). The presence of tannin in feedstuffs may be either beneficial or harmful based on its level in the feedstuffs and its inclusion levels in animal feeds. Generally, high tannin levels of more than 5 per cent may affect ruminant's productivity which is governed by intake and nutrient utilization efficiency (Li *et al.,* 2024). However, tannin levels less than 5 per cent may have a positive effect on animal production which includes reduced rumen protein degradation resulting in improved milk production, reduced internal parasitic load of animals and reduced methanogenesis in ruminants (Pellikaan *et al.,* 2011; Moate *et al.,* 2014; Besharati *et al.,* 2022; Min *et al.,* 2022, Lakhani *et al.,* 2023).

In the present study, the total tannin content of Grape pomace was found to be 4.67 per cent. However, Abarghuei *et al.* (2015) and Vinyard *et al.* (2021) reported higher values of 4.97 and 5.51 per cent respectively. The variations in total tannin content reported by several studies may be due to variations in the variety of grapes, stage of maturity, different soil and climatic conditions. Hence,inclusion of grape pomace in livestock feed may benefit both large and small ruminants by protecting the protein from being broken down by rumen microbes (Rumen by pass technology), which would result in a significant rise in milk production.

In vitro degradability studies, total gas production and methane production

The *in vitro* ruminal fermentation values such as total gas production at 24 and 48 hours, *in vitro* dry matter degradability (IVDMD), organic matter digestibility (OMD), Metabolizable energy (ME), Net energy for lactation (NE_L), Short chain fatty acids (SCFA), total methane production and methane production percent are tabulated in Table 2. The *in vitro* gas production volumes at different incubation times are presented in the Graph 1.

Evaluating the digestibility of feeds is important in determining the amount of nutrients that will be effectively utilized by the animal and assessing the quality of that feed. The current *in vitro* studies revealed that, total gas production obtained from one gram of grape pomace was 190 ml and 220 ml in 24 hrs and 48 hrs of incubation respectively. The *in vitro* dry matter degradability, organic matter digestibility and metabolizable energy values were 19.29, 56.33 per cent and 7.93 MJ/Kg respectively.

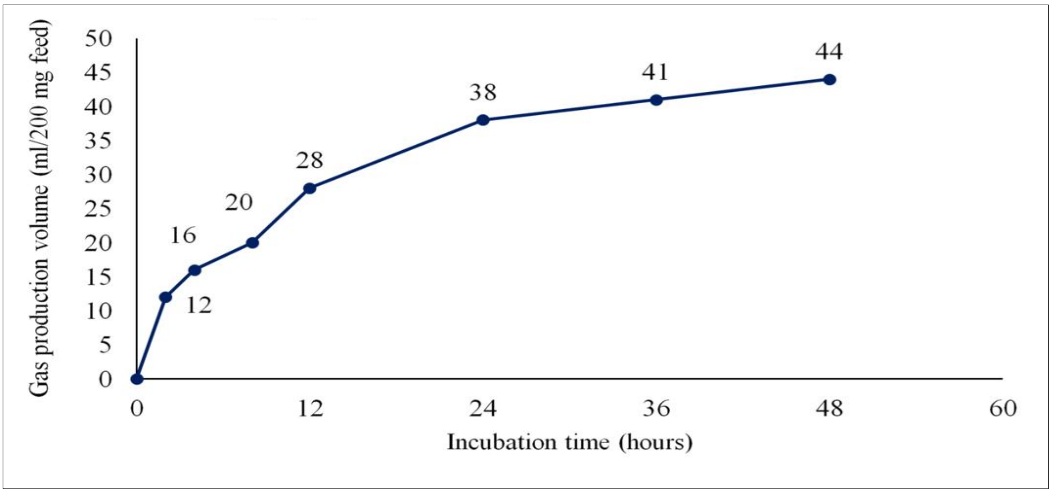
Since chemical composition is one of the most significant indicators of the nutritional value of feeds, variations in the chemical composition of grape pomace might cause variation in nutritive value. Such variation may also cause variation in the non-fibrous carbohydrates, organic matter and soluble sugar contents which in turn may cause changes in the volume of *in vitro* gas production (Maheri-sis *et al.,* 2008). The *in vitro* dry matter degradability

Table 1: Nutrient composition of grape pomace (On dry matter basis) (N= 6).

Nutrient composition (%)	Grape pomace
Dry matter	79.60±0.19
Crude protein	13.17±0.31
Ether extract	12.89±0.25
Total ash	2.68±0.16
Crude fibre	55.28±0.27
NFE	15.98±0.52
NDF	55.24±0.51
ADF	52.88±0.49
NFC	16.02±0.32
Calcium	0.50±0.08
Phosphorus	0.31±0.07
Total tannin	4.67±0.33

Table 2: *In vitro* ruminal fermentation values of grape pomace.

Total gas production at 24 hours (ml)/200 mg	38.00
Total gas production at 48 hours (ml)/200 mg	44.00
In vitro dry matter degradability - IVDMD (%)	19.29±0.27
Organic matter digestibility - OMD (%)	56.33±0.17
Metabolizable energy - ME (MJ/Kg)	7.93±0.02
Net energy for lactation - NE_L (MJ/Kg)	4.25
Short-chain fatty acids - SCFA (mmol)	8.43
In vitro methane production (ml)	4.72
In vitro methane production (%)	12.42



Graph 1: *In vitro* gas production volume at different incubation times.

(IVDMD) and organic matter digestibility (OMD) in the present study were lower than the findings of Runjun Dowarah *et al.* (2018). The variation in the IVDMD and OMD may be due to the differences in the variety, environmental conditions, processing methods and the animal species that was used for *in vitro* gas production studies. However, the lower IVDMD in the current study could be due to the presence of more stem compared to seeds and pulp portion in the Grape pomace (Runjan Dowarah *et al.,* 2018).

Likewise, the gas production was lower than the reports of Kara and Oztas (2023) Though the quantity of fermentable carbohydrates is a major factor influencing gas production, especially methane, the higher fat content in ruminant ration may also reduce the gas and methane production minimally (Atalay, 2020). In the present study, the fat content was found to be 12.89 per cent and the total gas production at 24 hours and methane production were found to be 38 and 4.72 ml respectively. Our present findings might be supported by the above theory and the facts of Johnson and Johnson (1995) who stated that the higher level of fat in Grape pomace may exert its negative effects on gas and methane production through inhibition of the activity of methanogenic archaea, protozoans and biohydrogenation of fatty acid.

The calculated ME, NE_L and SCFA (mmol) in the current study were higher than Runjun Dowarah *et al.* (2018) Generally, in ruminants short chain fatty acids (SCFA) supplies up to 80 % of their ME requirement due to microbial fermentation of dietary fibres. It also accounts for 50-70 % of digestible energy intake (Runjan Dowarah *et al.,* 2018). In the current study, the SCFA, ME and NeL values of Grape pomace were 8.43 mmol, 7.93 MJ/Kg and 4.25 MJ/Kg respectively. The higher SCFA may be due to the high fibre content (55.28%) which is positively correlated with the higher ME and NE_L values.

Grape pomace can be given to the animals in the form of a meal after proper drying. The two common methods of preserving Grape pomace are drying and ensiling. For easy usage of undegenerated leftovers and to maintain nutritional quality, the Grape pomace can be ensiled and stored for longer periods for its usage as livestock feed. Correct usage of this by-product can help to replace fodders that are not enough for all the livestock and especially for ruminants.

CONCLUSION

Based on the chemical composition and nutritive values, dried Grape pomace may be included as an unconventional feed resource in Total mixed ration to reduce the production cost without compromising the nutritive value of Total Mixed Ration of ruminants. Hence, grape pomace obtained from the byproduct of the fruit processing industry may be taken into consideration as an alternative feed resource for livestock.

ACKNOWLEDGEMENT

The authors are very much grateful to the authorities of Tamil Nadu Veterinary and Animal Sciences University especially The Dean, Veterinary College and Research Institute, Theni for accorded permission and necessary facilities provided to carry out this research work.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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