

Imprint:

Issue : 9
Year: 2026
Page: 132 - 144



Ali Nabeel Abdulqader
ABDULQADER ^{a*}
Muhlis MACİT ^b

^aAtaturk University,
alinabil199282@gmail.com
ORCID:0000-0001-8719-4394
^b Ataturk University,
mmacit@atauni.edu.tr
ORCID : 0000-0002-5055-1156

* Corresponding Author
mmacit@atauni.edu.tr

Atıf:

Ali Nabeel Abdulqader ABDULQADER
, Muhlis MACİT , (2026). In Vitro
Evaluation Of Partially Destoned Olive
Cake As An Alternative Roughage Source
In Dairy Cattle Tmr. *ETHABD*, 9, 132 -
144.
<https://doi.org/10.28949/ethabd.2026491>

IN VITRO EVALUATION OF PARTIALLY DESTONED OLIVE CAKE AS AN ALTERNATIVE ROUGHAGE SOURCE IN DAIRY CATTLE TMR

Abstract

The purpose of this study was to determine the effects of replacing dry meadow grass (DMG) with partly destoned olive cake (OC) at different rates in total mixed rations (TMR) for dairy cattle on *in vitro* gas and methane production, performance traits, *in vitro* digestion and some rumen parameters. In this study, OC obtained from a local olive oil production factory in the Milas District of Muğla Province was used to form experimental groups (P0, P25, P50, P75 and P100) by substituting 0%, 25%, 50%, 75% and 100% of dry meadow grass (DMG) in the total mixed ration (TMR) of dairy cattle. The suitability of OC for use in place of DMG in dairy cattle rations was determined using the Hohenheim *in vitro* gas production technique. Significant differences ($P<0.01$) were found among the groups in estimated performance parameters, such as 24-hour *in vitro* gas production, metabolic energy (ME), net energy for lactation (NE_L), and organic matter digestibility (OMD). The highest gas production was observed in the P25 group (112.59 ml), while the lowest was in the P100 group (95.82 ml). Among the groups, the P25 group exhibited the highest ME, NE_L, and OMD values ($P<0.01$). Differences among the groups were significant in terms of *in vitro* true digestible dry matter (IVTDDM) and true digestion degree (IVTDD) ($P<0.05$). The P25 group, which was similar to the control group, had the highest IVTDDM and IVTDD values. Differences among the groups in terms of mean values for the partition factor (PF), microbial protein production (MPP), and microbial protein synthesis efficiency (MPSE) were not significant. While differences among the groups in terms of total volatile fatty acids (TVFA) and ammonia nitrogen (NH₃-N) were not significant, pH values were significant ($P<0.05$). In conclusion, partially destoned olive cake (PDO) may be used at a rate of 25% instead of DMG as an alternative roughage source in dairy cattle TMRs.

Keywords: Olive cake, dry meadow grass, *in vitro* gas production, methane, feed value, TMR.



Kısmen Çekirdeği Uzaklaştırılmış Zeytin Posasının Süt Sığırlarında Alternatif Bir Kaba Yem Kaynağı Olarak İn Vitro Değerlendirilmesi

Öz

Bu çalışmanın amacı, süt sığırları için hazırlanan toplam karma rasyonlarda (TMR) kuru çayır otunun (KÇO) farklı oranlarda kısmen çekirdeği uzaklaştırılmış zeytin posası (ZP) ile ikame edilmesinin *in vitro* gaz ve metan üretimi, tahmini performans özellikleri, *in vitro* sindirim ve bazı rumen parametreleri üzerine etkilerini belirlemektir. Çalışmada, Muğla ili Milas ilçesinde faaliyet gösteren yerel bir zeytinyağı üretim tesisinden temin edilen zeytin posası (ZP) kullanılmıştır. Süt sığırlarına yönelik toplam karma rasyonda (TMR) bulunan kuru çayır otunun (KÇO) sırasıyla %0, %25, %50, %75 ve %100 oranlarında ZP ile ikame edilmesiyle P0, P25, P50, P75 ve P100 deneme grupları oluşturulmuştur. Zeytin posasının süt sığırları rasyonlarında KÇO yerine kullanım uygunluğu, Hohenheim *in vitro* gaz üretim tekniği kullanılarak

Screened by



Except where otherwise noted, content
in this article is licensed under a
Creative Commons 4.0 International
license. Icons by Font Awesome.

belirlenmiştir. Yirmi dört saatlik *in vitro* gaz üretimi, metabolik enerji (ME), laktasyon net enerjisi (NEL) ve organik madde sindirilebilirliği (OMS) gibi tahmini performans parametreleri bakımından gruplar arasında önemli farklılıklar belirlenmiştir ($P<0,01$). En yüksek gaz üretimi P25 grubunda (112,59 ml), en düşük gaz üretimi ise P100 grubunda (95,82 ml) saptanmıştır. Gruplar içerisinde en yüksek ME, NEL ve OMS değerleri P25 grubunda belirlenmiştir ($P<0,01$). *In vitro* gerçek sindirilebilir kuru madde (IVTDDM) ve gerçek sindirim derecesi (IVTDD) bakımından gruplar arasındaki farklılıklar önemli bulunmuştur ($P<0,05$). Kontrol grubuna benzer sonuçlar gösteren P25 grubunda, en yüksek IVTDDM ve IVTDD değerleri elde edilmiştir. Partisyon faktörü (PF), mikrobiyal protein üretimi (MPP) ve mikrobiyal protein sentez etkinliği (MPSE) ortalama değerleri bakımından ise gruplar arasındaki farklılıkların istatistiksel olarak önemli olmadığı belirlenmiştir. Toplam uçucu yağ asitleri (TUYA) ve amonyak azotu ($\text{NH}_3\text{-N}$) bakımından gruplar arasında istatistiksel olarak önemli bir farklılık belirlenmezken, pH değerleri bakımından gruplar arasındaki farklılık önemli bulunmuştur ($P<0,05$). Sonuç olarak, kısmen çekirdeği uzaklaştırılmış zeytin posasının (PDOC), süt sığırtı toplam karma rasyonlarında kuru çayır otunun yerine %25 oranında alternatif bir kaba yem kaynağı olarak kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Zeytin Posası, Kuru Çayır Otu, İn Vitro Gaz Üretimi, Metan, Yem Değeri, Toplam Karma Rasyon (TMR).

Introduction

Roughage and concentrate feed, which play a major role in the livestock industry, are used to meet the nutritional requirements of livestock. Farmers are experiencing difficulties in sourcing these feedstuffs due to rising prices. Although roughage is of great physiological importance in the nutrition of ruminants, the production of high-quality roughage in Turkey remains at 74.2 million tonnes per year (including 13.6 million tonnes from grazing lands), whereas the required amount is 95.3 million tonnes (TÜİK 2021). In fact, there is a shortage of approximately 21 million tonnes of high-quality roughage.

The lack of a sufficient supply of high-quality roughage to meet demand in every season of the year means that animals cannot be fed adequately. However, for livestock farming to be economically viable, high-quality roughage sources must be obtained as economically as possible in every season. It is reported that feeding and feed costs account for 70% of production expenses in livestock farms (Ergün et al. 2011). For this reason, recently researchers have focused intensively on enhancing the nutritional value of certain low-quality alternative roughage sources and their application in ruminant rations (Vasta et al. 2008). In these studies, emphasis is placed on the use of vegetable waste from the human food supply chain (Mousa 2011), fruit waste (Tadayon et al. 2017), sugar factory waste (Omer et al. 2013), oil (Tufarelli et al. 2013), and by-products or waste from the barley-based beverage industry in animal feeding, and this practice contributes both to protecting the environment and increasing business revenue by reducing feed costs (Korkmaz 2014). Alternative roughage sources play a significant role in reducing feed costs by substituting feeds within the same nutrient group for one another. From this perspective, alternative roughage sources can be defined as those that are more economical than others or that offer certain nutritional advantages over conventional feedstuffs. Korkmaz (2014) defined the alternative raw materials as those which have not been used in the conventional manner, whose chemical composition has not been fully characterised, or for which the inclusion rate in the total mixed ration (TMR) has not been determined. The insufficient knowledge regarding the chemical composition and energy values of alternative feed sources is one of the factors limiting their use in rations. It has been reported that, in order for feed sources to be utilised to the desired level in animal nutrition, laboratory analyses of parameters such as dry matter, crude protein, tannin, crude fibre, ether extract, and crude ash must be carried out (Abbeddou et al. 2011).

The olive tree (*Olea europaea* L. (Oleaceae)), which is associated with human civilisation and belongs to the olive family, is cultivated and used for olive production primarily in countries along the Mediterranean coast. Generally, the weight of an olive ranges from 2 to 12 grams; the olive pit ratio is 13-30%, the pulp content is 66-85%, and the fruit skin content is 1.5-3.5% (Aksoy 2012). According to TÜİK data (2022a), of the 2,976,000 tons of olives produced annually, 938,217 tons are utilized as table olives, while 2,037,783 tons are used for oil production. From 100 kg of oil olives processed in a mill, 15-22 kg of olive oil and 35-45 kg of olive cake (OC) are obtained, and from 100 kg of olive cake, approximately 6.0-7.5 kg of OC oil and 60-70 kg of dry olive cake are produced.

Considering these values, approximately 30 kg of dry olive cake is produced from 100 kg of oil-bearing olives. Olive production in Turkey increased by 71.2% in 2022 compared with the previous year, reaching 2,976,000 tonnes (TÜİK 2022b). In the same year, 611,334 tonnes of olive cake were obtained from 2,976,000 tonnes of olives. Morgan and Trinder (1980) reported that olive cake containing approximately 950-1075 kcal/kg DM of metabolic energy (ME) and consisting of the stone, skin and fruit pulp can be used in ruminant rations either on its own or in combination with high-quality roughage, thereby contributing to the national economy.

Olive oil is extracted from olives using pressing (traditional batch method), centrifugation (modern continuous method) or selective filtration (percolation) (Gümüşkesen 1999). Of these methods, the most widely used today is centrifugation, which is a fast and modern technique. Therefore, the oil content in the olive cake varies depending on the method used to extract the oil from the olives during the production process. To determine the nutritional value of animal feeds, various methods (*in vitro* and *in vivo*) are used to assess their nutrient content, digestibility and rate of digestion. Sadeghi et al. (2009) expressed that analysing feeds using the *in vivo* method is more difficult and costly than the *in vitro* method. Furthermore, in *in vivo* studies, mortality may occur when testing alternative feedstuffs on economically valuable animals. Kamalak et al. (2005) stated that the potential nutritional values and methane gas production of forage crops investigated using the *in vitro* gas production method can be determined more rapidly. It has been reported that estimating the digestibility of feeds using the *in vitro* gas production technique showed a strong relationship ($R = 0.98$, $SD = 0.25$) with *in vivo* digestibility method (Menke et al. 1979; Gürsoy and Macit, 2014).

The potential for using the by-products of olives-an agricultural product produced in large quantities (olive leaves, olive cake, black water)-in animal feed is being investigated more and more each day. Olive cake, one of the by-products of the olive industry whose suitability for animal feed is being investigated, consists of the skin, pulp and stone-containing portion remaining after the olives have been pressed. Differences in the chemical composition of olive cake may vary depending on the oil extraction method, the degree of extraction, the geographical location where the olives were grown, and the year of harvest (Alcaide et al. 2003; Mioc et al. 2007). As olives contain a high amount of oil, waste products from the olive oil industry are used in animal feed alongside other high-quality feedstuffs to increase both the quantity and quality of the product (Keleş 2015). The use of these products-particularly olive cake with the stones partially or completely removed-in the feeding of dairy cattle increases both milk yield and the level of oleic acid (C18:1 ω -9) in the milk. It also enriches the milk's lipid content by reducing the saturated fatty acids (Molina-Alcaide and Yanez Ruiz 2008).

In the current study, experimental groups were formed by partially substituting the dry meadow grass (DMG) present in the TMR of lactating cows with partially destoned olive cake (PDOC) at rates of 0%, 25%, 50%, 75% and 100%. The aim of present study was to determine the *in vitro* gas and methane production values, as well as *in vitro* digestibility and some rumen parameters, in order to assess the suitability of olive cake as an alternative roughage source.

Material and Methods

The concentrate feed (milk feed), alfalfa, dry meadow grass and maize silage used in the total mixed ration (TMR) for dairy cattle were obtained from the Atatürk University Food and Livestock Research and Application Center (39°54'25.5"N, 41°13'42.1"E), olive cake (skin, pulp and stones), substituted for dry meadow grass at various ratios (0, 25, 50, 75, 100%), was supplied by a local olive oil factory in Milas District, Muğla Province (November 2020). A shovelful was taken from each of seven different locations-the top, the centre and the sides-of the air-dried, piled olive cake mass, and these samples were mixed thoroughly to ensure homogeneity. A sufficient quantity of olive cake for the study was taken from this mixture and brought to the Feed Analysis Laboratory of the Department of Animal Science. After partially separating the stone fractions from the OC using a sieve, experimental rations (TMRs) were formulated by incorporating the material at varying levels-replacing dry meadow hay-into the diet of lactating cows in the third stage of lactation (days 140-305). The feed raw materials brought to the feed analysis laboratory were prepared for analysis by

grinding them in a mill so that they passed through a 1 mm sieve, in accordance with the method described by Canbolat (2019). The nutrient composition of partially destoned olive cake was determined in three replicate using the Weende analysis method (AOAC 1990). The content of NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin) was defined according to the method reported by Van Soest et al. (1991). The chemical composition of olive cake is presented in Table 1, the composition of feed ingredients for the ration mixtures (TMR)-prepared to be isonitrogenous (CP: 13.26-13.94%) and isocaloric (8.56-8.93 MJ/kg DM)-using the nutrient values specified in standards for each feed ingredient and the equations reported by Dugmore (1995) for ruminants is given in Table 2.

Table 1. Nutrient composition of olive cake

Nutrient composition (%)	PDOC
DM	93.31
CA	4.13
EE	4.09
CP	10.31
NDF	77.98
ADF	59.34
ADL	50.10

DM: Dry matter, CA: Crude ash, EE: Ether extract, CP: Crude protein, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin

Table 2. Feed Ingredient Composition of the Total Mixed Rations (TMR) (%)

TMRs	P0	P25	P50	P75	P100
Maize Silage	34	34	34	34	34
Dry Meadow Grass	24	18	12	6	0
Alfalfa Hay	14	14	14	14	14
Concentrate Feed	28	28	28	28	28
PDOC	0	6	12	18	24
Total (%)	100	100	100	100	100

P0: 0% olive cake, P25: 25% olive cake, P50: 50% olive cake, P75: 75% olive cake, P100: 100% olive cake.

The rumen fluid required to determine gas production parameters using the *in vitro* technique was taken immediately after slaughter from three Morkaraman sheep with fully developed rumens, aged 1.5-2.0 years and with an average live weight of 57-66 kg, for which slaughter approval has been obtained from the ethics committee of the Erzurum Meat and Milk Board. It was collected in accordance with the method described by Kılıç and Abdiwali (2016), placed in a thermos filled with water at 39°C, and transported as quickly as possible to the Feed Analysis Laboratory of the Department of Animal Science. The method defined by Goel et al. (2008) was applied to determine methane production. The values for metabolic energy (ME), net energy lactation (NE_L) and organic matter digestion degree (OMSD) of the samples from the prepared TMR groups were calculated using the using the crude protein, ether extract, crude ash contents of the feed samples and the net gas production values of 0.2 g of feed after 24 hours and formulas developed by Menke and Steingass (1988).

$$\text{ME (MJ/kg DM)} = 1.68 + (0.1418 \times \text{GP}) + (0.0073 \times \text{CP}) + (0.0217 \times \text{EE}) - (0.0028 \times \text{CA})$$

$$NE_L \text{ (MJ/kg DM)} = -0.06 + (0.1047 \times GP) + (0.0049 \times CP) + (0.013 \times EE) - (0.001 \times CA)$$

$$OMSD \text{ (\%)} = 14.88 + (0.8893 \times GP) + (0.448 \times CP) + (0.651 \times CA)$$

(GP: Net gas production (ml) of a 200 mg dry feed sample after 24 hours of incubation, CP: % crude protein, EE: % ether extract, and CA: % crude ash)

The pH of the rumen fluid was measured using a pH meter in samples remaining in glass syringes following a 24-hour incubation. The true digestion degree (IVTDD), *in vitro* true digestible dry matter (IVTDDM), microbial protein production (MPP), partition factor (PF) and microbial protein synthesis efficiency (MPSE) were determined according to the method reported by Blümmel et al. (1997). The total volatile fatty acid (Markham, 1942) and the NH₃-N nitrogen content (Blümmel et al., 1997) of the rumen fluid used in the *in vitro* gas production technique were measured immediately before it was used.

Statistical analyses

An analysis of variance (ANOVA) was applied to the data obtained at the end of the experiment, and Duncan's multiple range test was used to compare the means found to be statistically significant (Yıldız and Bircan 1991). The SPSS 20.0 software package (IBM Corp., USA) was used for all statistical analyses.

Results and Discussion

Chemical Composition of the Olive Cake (OC) and Total Mixed Rations (TMRs)

The use of partially destoned olive cake in ruminant nutrition is more widespread than that of other by-products. The chemical composition of olive cake used in the total mixed rations (TMR) of dairy cattle at different rates (0, 25, 50, 75 and 100%) instead of dry meadow grass (DMG) is presented in Table 1. Sansoucy (1985) stated that the dry matter (DM) content of olive cake was 75-80%. The DM content determined in the present study (93.31%) was higher than the reported values. In the study, the crude ash (CA) content of olive cake was detected to be 4.13%. While this value is similar to the 3-5% range reported by Sansoucy (1985), it is lower than the findings stated in some other studies (Canbolat et al. 2003; Yansari et al. 2007; Akbağ and Çetinkeşane 2021). The ether extract (EE) content of olive cake has been reported by numerous researchers (Yansari et al., 2007; Canbolat et al. 2003; Fayed et al., 2001; Lannaccone et al., 2019; Akbağ and Çetinkeşane, 2021), with defined values ranging from 3.40% to 17.07%. The ether extract value (4.09%) obtained in the current study was higher than that detected by Yansari et al. (2007), while it was lower than the values reported by Fayed et al. (2001), Keleş (2015), Dalkılıç (2018), Lannaccone et al. (2019) and Akbağ and Çetinkeşane (2021). This is because the oil percentage in olive cake varies depending on the rate of stone removal and the method used to extract oil from the olives during production processes.

Akbağ and Çetinkeşane (2021) determined the crude protein (CP) content of air-dried, de-stoned olive cake to be 5.63% on a dry matter basis. Sansoucy (1985) stated that olive cake contains between 5 and 10% crude protein (CP). The result obtained in the present study (10.31%, in dry matter) is in line with the upper limit stated by Sansoucy (1985) and Dalkılıç (2018), while it is higher than the values reported by other researchers (Canbolat et al. 2003; Martin-Garcia et al. 2006; Yansari et al. 2007; Keleş 2015). In current study, the NDF, ADF and ADL values for olive cake were determined to be 77.98%, 59.34% and 50.10%, respectively. The ADF value obtained was consistent with the ADF value (60.1%) reported by Canbolat et al. (2003). Other results regarding the NDF, ADF and ADL content of olive cake were found to be higher than the values reported for the same features by Canbolat et al. (2003), Martin-Garcia et al. (2006), Yansari et al. (2007) and Keleş (2015). Furthermore, Sansoucy (1985) expressed that olive cake contains 35-50% crude fibre (CF) and 950-1075 kcal/kg DM metabolic energy (ME). Generally, factors such

as the olive oil production method, the degree of extraction, the rate of stone removal, the geographical location where the olives were grown, the harvest period and year influence the chemical composition of the resulting olive cake (Alcaide et al. 2003; Mioc et al. 2007; Dalkılıç, 2018). These factors may limit the use of olive cake in the feeding of various types of livestock. Although influenced by numerous factors, raw olive cake is considered to possess sufficient nutritional value to meet the maintenance nutrient requirements of ruminants (Keleş, 2015).

The results of the chemical composition and variance analysis results of the dairy cattle TMRs are presented in Table 3. The TMRs were formulated to be isonitrogenous (CP: 13.26-13.94%) and isocaloric (8.56-8.93 MJ/kg DM) using the nutrient compositions reported in the standards for each feed ingredient and the equations defined by Dugmore (1995) for ruminants. Laboratory analyses were carried out on the DM, CA, EE, CP, NDF, ADF and ADL components of the total mixed ration formulations. Significant differences were observed between the groups for all parameters except crude ash (CA) ($P < 0.05$). There was a significant difference in dry matter (DM) content between the group P25 and groups the P0 (95.33%) and P50 (95.25%) ($P < 0.05$), whereas the differences between the other groups were insignificant. When rations containing olive cake were examined in terms of crude protein content, the P100 (15.14%) and P75 (14.93%) groups were similar and had higher values than the P50, P25 and P0 groups ($P < 0.05$). The lowest crude protein rate was determined in the control group. Crude protein content increased in line with the rise in the proportion of olive cake in the total mixed rations (TMRs).

Ether extract content increased depending on the rise in the proportion of olive cake in the TMRs, and the differences between the groups were found to be significant ($P < 0.05$). The addition of olive cake to the diet increased the ADF and ADL contents compared with dry meadow grass. Although the NDF levels of the mixed rations also rose as the olive cake content in the diet increased, the differences between the feed groups in terms of NDF values were not significant. The ADL levels of the TMR groups showed a similar trend to that observed for ADF, with the ADL level in the control group, which was 10.43%, increasing to 19.56% in the P100 group ($P < 0.05$).

Table 3. Chemical Composition of the Total Mixed Ration Groups (DM%)

TMR Groups	DM	CA	CP	EE	NDF	ADF	ADL
P0	95.33 ^b	7.44	14.50 ^d	3.66 ^e	63.23	33.40 ^c	10.43 ^c
P25	96.69 ^a	7.21	14.61 ^{cd}	3.94 ^d	63.55	35.10 ^{bc}	14.14 ^{bc}
P50	95.25 ^b	6.98	14.81 ^{bc}	4.15 ^c	63.86	35.61 ^{ab}	15.78 ^{ab}
P75	96.24 ^{ab}	6.66	14.93 ^{ab}	4.37 ^b	64.62	36.79 ^a	18.79 ^a
P100	95.91 ^{ab}	6.53	15.14 ^a	4.63 ^a	68.11	38.87 ^a	19.56 ^a
P	0.027	0.114	0.004	0.000	0.066	0.010	0.003
SEM	0.13	0.11	0.04	0.02	0.50	0.37	0.57

^{a-e}: Means with different letters in the same column differ significantly ($P < 0.05$). SEM: Standard error of the means, P0: 0% olive cake, P25: 25% olive cake, P50: 50% olive cake, P75: 75% olive cake, P100: 100% olive cake. DM: Dry matter, CA: Crude ash, EE: Ether extract, CP: Crude protein, NDF: Neutral detergent fibre, ADF: Acid detergent fibre, ADL: Acid detergent lignin

It has been expressed that the dry matter (DM) content of feed materials consumed by ruminant animals generally ranges between 88% and 92% (Ensminger et al. 1990; Pond et al. 1995). In this research, the dry matter contents of TMRs were found to be higher than the reported values. In ruminants, 25-32% NDF and 19-25% ADF levels are required to increase productivity and achieve the desired salivary secretion (Tekçe and Gül 2014). It has been reported that, among TMRs with similar ADF levels, those with a high lignin content adversely affect digestion in ruminants (Robinson 2003; Özdemir 2019). Kılıç (2006) stated that CA content exceeding 17% of dry matter could have negative effects. In the current study, the CA contents of the TMR samples ranged from 6.53-7.44%, and the differences in average crude ash content were insignificant.

***In Vitro* Gas and Methane Production and Estimated Performance Parameters of the TMR Groups**

The performance parameters estimated from the 24-hour *in vitro* gas and methane production and the variance analysis results of TMR groups are given in Table 4. As can be seen in the table, significant differences ($P<0.05$) were found between the experimental groups in terms of total gas production (ml/0.5 g DM), metabolic energy (ME-MJ/kg DM), net energy lactation (NE_L-MJ/kg DM) and organic matter digestibility (OMD, %). The data obtained for methane (ml and %) production were similar across the TMR groups. Ruminants meet their energy requirements for maintenance and production from their daily rations (Schingoethe, 2017). It has been reported that the daily NE_L requirement for dairy cows producing 10–30 litres of milk during lactation ranges 5.17-6.87 MJ/kg DM (NRC, 2001).

It has been reported that there is a negative correlation between acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents and gas production (Abdulrazak et al. 2000). An increase in NDF content reduces gas production (Doane et al. 1997; Calabro et al. 2001), whereas a decrease in NDF content arises gas production (Mertens et al. 1997).

Table 4. *In Vitro* Gas and Methane Production, Estimated Performance Parameters, and Variance Analysis Results for the TMR Groups.

TMR Groups	Gas (ml/0.5 DM)	Methane (ml)	Methane (%)	ME (MJ/kg DM)	NE_L (MJ/kg DM)	OMD
P0	104.72 ^b	17.82	17.02	7.78 ^b	4.44 ^b	63.47 ^b
P25	112.59 ^a	18.96	16.86	8.24 ^a	4.77 ^a	66.17 ^a
P50	101.98 ^{bc}	17.58	17.23	7.64 ^{bc}	4.33 ^{bc}	62.34 ^b
P75	97.19 ^{cd}	16.97	17.46	7.38 ^{cd}	4.13 ^{cd}	60.48 ^c
P100	95.82 ^d	17.15	17.89	7.31 ^d	4.08 ^d	60.00 ^c
P	0.000	0.072	0.302	0.000	0.000	0.000
SEM	0.76	0.20	0.15	0.04	0.03	0.25

^{a-d}: Means with different letters in the same column differ significantly ($P<0.05$). ME: Metabolic energy, NE_L: Net energy lactation, OMD: Organic matter digestibility

In the composition of the TMRs, the % NDF and ADF ratios of the experimental groups increased in relation to the rise in the amount of olive cake used in place of dry meadow grass. Differences between the ration mixtures were significant in terms of average total gas production ($P<0.01$). Some researchers (Moss et al. 2000; Nkrumah et al. 2006; Danielsson et al. 2017) stated that methane production in the rumen may be influenced by factors such as the energy content, quality and quantity of the feed or ration, dry matter intake, the quantity and type of carbohydrates undergoing fermentation in the rumen, the acetic /propionic acid ratio, and the animal's live weight and age. Other studies have indicated that differences in gas and methane production, as well as ME, NE_L and OMD values, may exist between experimental groups depending on the fermentation by rumen microorganisms, the amount of degradable matter in the feed, and the roughage/concentrate ratio (Musco et al. 2016; Algan et al. 2018). Sherasia et al. (2017) reported that methane production decreases as dry matter digestibility increases. It has been stated that methane values produced in the rumen by feed or feed mixtures falling within the range of $11\% < \text{CH}_4 \leq 14\%$ are classified as low anti-methanogenic (Lopez et al. 2010). In the present study, it was observed that the use of olive cake at different levels in place of DMG in TMRs had no effect on methane production. In the current study, it was detected that, with the exception of the P25 group, the degree of digestion decreased as the level of olive cake substituted for dry meadow grass in the other ration mixtures increased. Göncü ve Kaya (2024) reported that replacing DMG with 100% olive leaves in dairy cow rations reduced metabolic energy by 5.0% and NE_L by 6.6%. The values determined in this study for ME and NE_L were consistent with those determined by Göncü ve Kaya (2024).

***In Vitro* True Digestion Parameters and Microbial Protein Production Values of the TMR Groups**

In Vitro true digestion parameters, microbial protein production values and variance analysis results of TMRs are given in Table 5. Significant differences were observed between the experimental groups in terms of IVTDDM and IVTDD values ($P<0.05$). The P25 group was found to be similar to the control group but significantly higher than the other groups ($P<0.05$). The P100 group had the lowest IVTDDM value (249.00 mg) and was similar to the P75 and P50 groups in this respect. Similarly, the highest IVTDD values in the experimental groups were obtained from the P25 group at 57.39%. While the P25 group was similar to the control group in terms of IVTDD value, it differed significantly from the P50, P75 and P100 ration groups ($P<0.05$). The P100 group, which had the lowest IVTDD value (49.39%), was found to be similar to the P75 and P50 groups. There were no significant differences between the groups in terms of the partition factor (PF), microbial protein synthesis efficiency (MPSE) and microbial protein production (MPP). It has been reported that, in the nutrition of ruminants, 24-hour digestibility parameters should be taken into account alongside the total gas production from feeds (Blummel et al. 1997).

Arslan (2019) stated that as the amount of olive cake used in the ration increased, the values for ADF, NDF, dry matter and organic matter, as well as the digestibility of crude protein, decreased, however, these declines were not significant. In the present study, similarly to Arslan (2019) findings, it was observed that the addition of olive cake to the ration reduced the degree of digestibility. Significant differences were determined among the total mixed ration groups regarding IVTDDM and IVTDD values ($P<0.01$). The highest digestibility was recorded in the control and P25 groups, whereas the lowest values were found in the P50, P75, and P100 groups, which contained higher levels of olive cake.

Table 5. *In Vitro* True Digestion Parameters Microbial Protein Production values of TMRs

TMR Groups	IVTDDM (mg)	PF (mg/ml)	MPP (mg)	MPSE (%)	IVTDD (%)
P0	281.33 ^a	2.76	56.93	20.13	56.08 ^a
P25	291.33 ^a	2.66	50.06	17.17	57.39 ^a
P50	253.67 ^b	2.56	35.13	13.84	50.17 ^b
P75	250.33 ^b	2.66	42.06	16.80	49.93 ^b
P100	249.00 ^b	2.67	43.66	17.29	49.39 ^b
P	0.000	0.527	0.301	0.521	0.000
SEM	2.22	0.04	3.12	1.08	0.41

^{a-b}: Means with different letters in the same column differ significantly ($P<0.05$). IVTDDM: *In vitro* true digestible dry matter, PF: Partition factor, MPP: Microbial protein production, MPSE: Microbial protein synthesis efficiency, IVTDD: *In vitro* true digestion degree

According to Blummel et al. (1997) and Blummel and Lebzien (2001), as the degree of partition factor in feed increases, microbial protein synthesis efficiency, feed intake and digestibility also increase. Blummel et al. (1997) and Blummel and Lebzien (2001) reported that the partition factor generally ranged 2.75-4.41 mg/ml, and as for Baba et al. (2002) stated that a high partition factor increased feed intake and digestibility. The results obtained in the present study did not correspond with the findings of other researchers. This difference between the findings of those researchers and the results of the present study may be attributed to differences in the feed raw materials used in the rations, combined with their proportions and contents. It has been indicated that the primary aim of *in vitro* trials is to obtain more detailed information on feed composition (Blummel and Ørskov 1993). In a research study reporting that microbial protein is an important source of amino acids for ruminants, it was emphasised that, in *in vitro* trials, more than one parameter should be evaluated in combination rather than selecting based on a single parameter (Ceren

2021). In the present study, the addition of olive cake to the ration at different rates, in place of dry meadow grass, had no significant effect on microbial protein synthesis efficiency values.

TVFA, NH₃-N and pH Values of the TMR Groups

The mean values and the variance analysis results of rumen parameters such as TVFA (mmol/l), pH and NH₃-N (mg/l) for the TMR groups are presented in Table 6. Of these parameters, differences between the groups in terms of pH values were found to be significant ($P < 0.05$). The highest pH value among the trial groups was recorded in the P75 group. The P75 and P100 groups, and the P0, P25 and P50 groups, were similar to one another in terms of pH values. Lana et al. (1998) reported that rations with a high proportion of roughage increase not only rumen pH but also gas production in ruminants. Özel and Sarıççek (2010) observed that the optimum rumen pH should be 5.5-7.0. In the current study, it was determined that the pH values for the experimental groups ranged 6.40- 6.50, and that the pH increased in line with the rise in the proportion of olive cake in the ration. Fatehi et al. (2017) determined an inverse relationship between TVFA content and methane production. As for Göncü ve Kaya (2022) reported that TVFA content decreased in accordance with an increase in the addition of olive leaves to the diet. In the current study, however, unlike other researchers, it was found that the addition of olive cake to the ration did not significantly affect TVFA values.

Table 6. TVFA, NH₃-N and pH Values of Total Mixed Ration Groups

TMR Groups	pH	TVFA (mmol/l)	NH ₃ -N (mg/l)
P0	6.40 ^b	117.40	425.33
P25	6.41 ^b	119.73	433.33
P50	6.43 ^b	116.57	443.67
P75	6.50 ^a	106.02	455.67
P100	6.47 ^{ab}	106.92	428.67
P	0.037	0.081	0.274
SEM	0.01	1.69	4.51

a, b: Means with different letters in the same column differ significantly ($P < 0.05$). TVFA: Total volatile fatty acids, NH₃-N: Ammonia nitrogen

Generally, Keleş and Er (2023) carried out a feeding experiment related to the effect of voluntary intake of stoned olive cake (SOC) on performance traits of in Karya sheep yearlings and Saanen goats, and stated that the olive cake can be used in ruminant rations as alternative feedstuff. Also Chiofalo et al. (2004) investigated the effect of partially destoned olive cake on milk yield and characteristics in lactating ewes, and reported that olive cake was added at a rate of 20% to replace the alfalfa hay, wheat bran, and beet pulp contained in the complete ration prepared for the control group. The fact that studies conducted on dairy cattle using mixed rations containing different proportions of olive cake have yielded varying results regarding these parameters may be attributed to differences in the harvest period, geographical location where the olives were grown, the nutrient composition and the olive oil production method of the olive cake used (with the partially or completely destoned, or de-oiled), its form (silage, dry, pellet, etc.), combined with differences in the roughage–concentrate feed ratios of the rations.

Consequently, given that the P25 group exhibited the highest total gas production, ME, NE_L and OMD values, and that the P25 group also had the highest IVTDDM and IVTDD values being similar to those of the control group. It was concluded that partially destoned olive cake could be used at a rate of 25% in place of DMG as an alternative roughage source in dairy cattle TMRs, and that this conclusion should be supported by *in vivo* studies.

REFERENCES

- Abbeddou, S., Riwhi, S., Iniguez, L., Zaklouta, M., Hess, H.D., Kreuzer, M., 2011. Ruminant degradability, digestibility, energy content, and influence on nitrogen turnover of various Mediterranean by-products in fat-tailed Awassi sheep. *Animal feed science and technology*, 163(2-4), 99-110.
- Abdulrazak, S.A., Fujihara, T., Ondilek, J.K., Ørskov, E.R., 2000. Nutritive evaluation of some Acacia tree leaves from Kenya. *Animal Feed Science and Technology*. 85:89–98.
- Akbağ, H.I., Çetinkeşane, Ö., 2021. Farklı Üretim Sistemlerinden Elde Edilen Zeytinyağı Sanayi Yan Ürünlerin Besleme Değerinin Belirlenmesi. *ÇOMÜ Ziraat Fakültesi Dergisi*, 9(2), 202-210.
- Aksoy, B.F., 2012. Organik zeytin ve zeytinyağı üretimi. http://www.undp-pff.org/index.php?option=com_docman&task=doc_view&gid=70&Itemid=15 (Erişim: 13.09.2012).
- Alcaide, E.M., Ruiz, D.Y., Moumen, A., Garcia, I.M., 2003. Chemical composition and nitrogen availability for goats and sheep of some olive by-products. *Small Ruminant Research*, 49(3), 329-336.
- Algan, D., Aydın, I., Ocak, N., 2018. Economic Analysis of Fertilization Based on The Nutritional Value of Rangeland: A New Opinion. *Anadolu Journal of Agricultural Science*, 1(33): 246-253.
- AOAC., 1990. Official method of analysis. Association of Official Analytical Chemists, 15th ed. s.66-88. Washington, DC, USA.
- Arslan O., 2019. Rasyonda farklı düzeylerde kullanılan fermente zeytin küspesinin ham besin maddeleri sindirimi üzerine etkileri. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü/ Zootečni Ana Bilim Dalı, Aydın Adnan Menderes Üniversitesi.
- Baba A.S.H., Castro F.B., Orskov, E.R., 2002. Portioning of energy and degradability of browse plants in vitro and the implications of blocking the effects of tannin by addition of polyethylene glycol. *Animal Feed Science and Technology*, 95:93-104.
- Blummel, M., Lebzien, P., 2001. Predicting ruminal microbial efficiencies of dairy rations by in vitro techniques. *Livestock Production Science*, 68(2-3), 107-117.
- Blummel, M., Makkar, H.P.S., Chisanga, G., Mtumuni, J., Becker, K., 1997. The prediction of dry matter intake of temperate and tropical roughages from in vitro digestibility/gas-production data, and the dry matter intake and in vitro digestibility of African roughages in relation to ruminant liveweight gain. *Animal feed science and technology*, 69(1-3), 131-141.
- Blummel, M., Ørskov E.R., 1993. Comparison of in vitro gas production and nylon bag degradabilities of roughages in predicting food intake of cattle. *Animal Feed Science and Technology*, 40, 109-119.
- Calabro, S., Ifascelli F., Moniello G., Piccolo V., 2001. In vitro degradability of three forages: fermentation kinetics and gas production of NDF and neutral detergent-soluble fraction of forages. *Journal of the Science of Food and Agriculture*, 82, 222-229
- Canbolat, Ö., 2019. Yemlerin Bulundukları Yere Göre Örnek Alma ve Yem Analizleri. Yem Analiz Yöntemleri ve Yem Değerlendirme, 1. Baskı, Medyay Kitapevi, s.616, Türkiye.
- Canbolat, Ö., Karabulut A., Gürbüzol., F., 2003. Zeytin ağacı dal ve yaprakları ile zeytin küspesinin yem değerinin *in vivo* ve *in vitro* yöntemlerle saptanması. III. Ulusal Zootečni Bilim Kongresi, Ankara, 332-342.
- Ceren, B., 2021. Bazı Üzüm Cibrelerinin Ruminantlar için Potansiyel Besleme Değeri ve Anti-metanojenik Potansiyelinin Belirlenmesi. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, Kahramanmaraş Sütçüimam Üniversitesi.
- Chiofalo, B., Liotta, L., Zumbo, A., Chiofalo, V., 2004. Administration of olive cake for ewe feeding: effect on milk yield and composition, *Small Ruminant Research*, 2004, 55: 169-176.
- Dalkılıç B., 2018. Zeytinyağı Endüstrisi Yan Ürünlerinin Hayvan Besleme Alanında Değerlendirilme Olanakları. *El-Cezerî Fen ve Mühendislik Dergisi*, 5(3);917-926.
- Danielsson, R., Ramin M., Bertilsson J., Lund P. and Huhtanen P., 2017. Evaluation of a gas in vitro system for predicting methane production in vivo. *Journal of Dairy Science*, 100 (11), 8881-8894.
- Doane, P.H., Schofield, P., Pell, A.N. 1997. Neutral detergent fiber disappearance and gas and volatile fatty acid production during the in vitro fermentation of six forages. *J. Anim. Sci.* 75: 3342 – 3352.
- Dugmore, T.J., 1995. Characteristics of common roughages for dairy cows in KwaZulu-Natal. In: *Dairying in KwaZulu-Natal*. KwaZulu-Natal Department of Agriculture.
- Duru, A.A., Kaya, Ş., 2015. Zeytin Posası Silajının Hayvan Beslemede Kullanım Olanakları, *MKÜ Ziraat Fakültesi Dergisi*, 20(1):64-7

- Ensminger, M.E., Oldfield, J.E., Heinemann, W.W., 1990. "Feeds and Nutrition". 2nd ed., The Ensminger Publishing Company. ISBN 0 941 21 80 82, Clovis, California.
- Ergün A., Tuncer S.D., Çolpan, İ., Yalçın S., Yıldız G., Küçükersan K., Küçükersan S., Şehu A., Saçaklı P., 2011. Hayvan Besleme ve Beslenme Hastalıkları, Pozitif Matbaacılık, ISBN:975-97808-2-8.
- Fatehi, F., Zali A., Dehghan-Banadaky M. and Danesh Mesgaran M., 2017. The study of synchrony effect of starch and rumen degradable protein concentrations by gas production technique. *Journal of Animal Science Researches*, 26(4), 121- 141.
- Fayed, A. M., Youssef, K.M., Abou E.L., Naser, H.M., 2001. Nutritional performance of goats fed non-conventional diets based on olive pulp in Sinai. s.139-154.
- Goel, G., Makkar, H.P.S., Becker, K., 2008. Effect of sesbania sesban and carduus pycnocephalus leaves and fenugreek (*Trigonella foenum-gaecum* 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.
- Göncü, M. & Kaya, H., 2024. Zeytin yaprağının (*Folium Olivae*) süt sığırları toplam rasyon karışımlarında (TMR) kuru çayır otu yerine ikame edilebilirliğinin *in vitro* gaz üretim tekniği ile belirlenmesi. *Menba Kastamonu Üniversitesi Su Ürünleri Fakültesi Derg*, 10 (1), 106-114.
- Gümüşkesen, A.S., 1999, Bitkisel yağ teknolojisi. Asya Tıp Yayıncılık Ltd., s.182, İzmir.
- Dalkılıç B., 2018. Zeytinyağı Endüstrisi Yan Ürünlerinin Hayvan Besleme Alanında Değerlendirilme Olanakları. *El-Cezeri Fen ve Mühendislik Dergisi*, 5(3);917-926.
- Gürsoy, E. ve Macit, M., 2014. Erzurum ili meralarında doğal olarak yetişen bazı buğdaygil yem bitkilerinin *in vitro* gaz üretim değerlerinin belirlenmesi. *Yüzüncü Yıl Üniv. Tar. Bil. Derg.*, 24 (3): 218-227.
- Kamalak, A., Canbolat, O., Gurbuz, Y., Erol, A., Ozay, O., 2005. Effect of maturity stage on chemical composition, *in vitro* and *in situ* dry matter degradation of tumbleweed hay (*Gundelia tournefortii* L.). *Small Ruminant Research*, 58(2), 149-156.
- Keleş, G., 2015. Zeytin Posasının Ruminantlar İçin Besin ve Besleme Değeri. *Turkish Journal of Agriculture-Food Science and Technology*. October DOI: 10.24925/turjaf.v3i10.780-789.435.
- Keleş, G. and Er, M. 2023. Comparison of sheep and goat preferences for different forms of stoned olive cake. *Tropical Animal Health and Production*, 55:203
- Kılıç, A., 2006. Kaba Yemlerde Niteliğin Saptanması. Yardımcı Ders Kitabı, s.159, Hasad Yayıncılık.
- Kılıç, Ü., Abdiwali, M.A., 2016. Determination of *in vitro* true digestibilities and relative feed values of wine industry gape residues as alternative feed source. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 22(6), 895-901.
- Korkmaz, F., 2014. Raf Ömrü Dolan Bazı Gıdaların Ruminant Beslemede Alternatif Yem Kaynağı Olarak Kullanım Olanaklarının Araştırılması. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, Namık Kemal Üniversitesi, Tekirdağ.
- Lana, R.P., Russell, J.B., & Van Amburgh, M.E., 1998. The role of pH in regulating ruminal methane and ammonia production. *Journal of animal science*, 76(8), 2190-2196.
- Lannaccone, M., Laani, A., Ramazzotti, S., Gotta, L., Marone, E., Cichelli A., Martino G., 2019. Whole Blood Transcriptome Analysis Reveals Positive Effects of Dried Olive Pomace-Supplemented Diet on Inflammation and Cholesterol in Laying Hens. *Department of Medical, Oral and Biotechnological Sciences*, G. D'Annunzio University, Via dei Vestini, 31, 66100 Chieti, Italy.
- Lopez, S., Makkar, H. P., Soliva, C. R., 2010. Screening plants and plant products for methane inhibitors. *In vitro* screening of plant resources for extra-nutritional attributes in ruminants: nuclear and related methodologies. s.191-231). Springer, Dordrecht.
- Markham, R., 1942. A Steam Distillation Apparatus Suitable for Micro-Kjeldahl Analysis. *Biochemical Journal*, 36(10-12), 790.
- Martin-Garcia, A. I., Yanez-Ruiz, D. R., Moumen, A., Molina-Alcaide, E., 2006. Effect of polyethylene glycol, urea and sunflower meal on olive (*Olea europaea* var. *europaea*) leaf fermentation in continuous fermentors. *Small Rumin. Res.* 61:53-61.
- 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*. *The Journal of Agricultural Science*, 93(1), 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.

- Mertens, D.R., Weimer, P.J., Waghorn, G.C., 1997. Inocula differences affect *in vitro* gas production kinetics. USA Dairy Forage Research Center, 1997 Research Summaries, p.53-54.
- Mioc, B., Pavic V., Vnuecec I., Prpic Z., Kostelik A., Subic V., 2007. Effect of olive cake on daily gain, carcass characteristics and chemical composition of lamb meat. Czech Journal of Animal Science, 52:31-36.
- Molina-Alcaide, E., Yanez-Ruiz, D.R., 2008. Potential use of olive by-products in ruminant feeding: A review. Animal Feed Science and Technology, 147:247-264.
- Morgan, D.E., Trinder H., 1980. The composition and nutritional value of some tropical and sub-tropical by-products. In: E.R. Ørskov (ed.), By-Products and Wastes in Animal Feeding. Occasional Publication No. 3, Br. Soc. Anim. Prod. s. 91-111.
- Moss, A.R., Jouany J.P.O. Newbold C.J., 2000. Methane production by ruminants: its contribution to global warming. Annals of Zootechnology, 49, 231-235.
- Mousa, M.R.M., 2011. Effect of partial replacement of dietary concentrate feed mixture by fodder beet roots on productive performance of ewes and doe goats under the conditions of North Sinai. Asian Journal of Animal Sciences, 5: 228-242.
- Musco, N., Koura, I.B., Tudisco, R., Awadjihè, G., Adjolohoun, S., Cutrignelli, M.I., Mullica, M.P., Houinato, M., Infascelli, F., Calabrò, S., 2016. Nutritional Characteristics of Forage Gown in South of Benin. Asian-Australasian journal of animal sciences, 29(1), 51.
- Nkrumah, J.D., Okine E.K., Mathison G.W., Schmid K., Li C., Basarab J.A., Price M.A., Ang Z., Moore S.S., 2006. Relationships of feedlot feed efficiency, performance, and feeding behavior with metabolic rate, methane production and energy partitioning in beef cattle. Journal of Animal Science, 84, 145-153.
- NRC 2001. Nutrient Requirements of Dairy Cattle. 7.ed. Washington, D.C. National Academy Press.
- Omer, H.A.A., Abdel-Magid S.S., El-Badawi Al.Y., Awadalla I.M., Mohamed M.I., Mona S., 2013. Nutritional impact for the whole replacement of concentrate feed mixture by dried sugar beet pulp on growth performance and carcass characteristics of Ossimi sheep. Life Sci. J.10:(4).
- Özdemir Ö., 2019. Erzurum ilinde yetişen bazı ağaç yapraklarının *in vitro* gaz üretim tekniğiyle yem değerlerinin belirlenmesi. Yüksek Lisans Tezi, Fen Bilimleri Enstitüsü, Atatürk Üniversitesi, Erzurum.
- Özel, O., Sarıççek, B., 2010. Ruminantlarda rumen mikroorganizmalarının varlığı ve önemi (derleme). TÜBAV Bilim Dergisi, 2(3), 277-285. <https://izlik.org/JA62MA62FM>
- Pond W.G., Church D.C., and Pond K.R., 1995. Basic Animal Nutrition and Feeding. John Wiley and Sons. New York.
- Robinson, P.H., 2003. Estimating Alfalfa Hay and Corn Silage Energy Levels UC Davis Equations using NDF and ADF. Cooperative Extension. University of California, Davis. <https://animalscience.ucdavis.edu/sites/g/files/dgvnsk446/files/inlinefiles/Web200309.pdf> (17.11.2018).
- Sadeghi, H.T., Yansari, A., Ansari-Pirsarai, Z., 2009. Effects of different olive cake by products on dry matter intake, nutrient digestibility and performance of Zell sheep. International Journal of Agriculture and Biology, 11: 39-43.
- Sansoucy, R., 1985. Olive by-products for animal feed (Vol. 43). Food & Agriculture Org.
- Schingoethe, D.J., 2017. A 100-Year Review: Total mixed ration feeding of dairy cows. Journal of dairy science, 100(12), 10143-10150.
- Sherasia, P.L., Pandya P.R., Parnerkar S., Murty S., Devalia B.R., 2017. *In vitro* digestibility and methane production as affected by incorporation of different levels of solid state fermented biomass in total mixed rations. Indian Journal of Animal Nutrition, 34 (4), 420-424.
- Tadayon, Z., Rouzbehan, Y., Rezaei, J., 2017. Effects of feeding different levels of dried orange pulp and recycled poultry bedding on the performance of fattening lambs. J. Anim. Sci, 95 (4): 1751-1765.
- Tekce, E., Gül, M., 2014. Ruminant beslemede NDF ve ADF'nin önemi. Atatürk Üniversitesi Veteriner Bilimleri Dergisi, 9(1), 63-73.
- Tufarelli V., Introna, M., Cazzato, E., Mazzei, D., Laudadio, V., 2013. Suitability of partly destoned exhausted olive cake as byproduct feed ingredient for lamb production. J. Anim. Sci. 91:872-877.
- TÜİK, 2021. Bitkisel Üretim İstatistikleri, <https://biruni.tuik.gov.tr/medas/>
- TÜİK, 2022a. <https://data.tuik.gov.tr/Kategori/GetKategori?p=Tarim-111>

TÜİK,2022b. <https://data.tuik.gov.tr/Bulten/Index?p=Bitkisel-Uretim-Istatistikleri-2022-45504>

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.

Vasta, V., Nudda, A., Cannas, A., Lanza, M., Priolo, A., 2008. Alternative Feed Resources and Their Effects on the Quality of Meat and Milk from Small Ruminants. Animal Feed Science and Technology, 147 223–246.

Yansari A.T., Sadeghi H., Ansari-Pirsarai Z., Mohammad-Zadeh H., 2007. Ruminal dry matter and nutrient degradability of different olive cake by-products after incubation in the rumen using nylon bag technique. Int. J. Agric. Biol., 2009- 3: 439-442.

Yıldız, N. ve Bircan, H., 1991. Araştırma ve Deneme Metotları. Atatürk Üniversitesi. Yayın No:697, Ziraat Fakültesi Yayınları No:305, Ders Kitapları Serisi No:57, Erzurum, s:277.



Research Article
10.55257/ethabd.2026491

Imprint:

Issue : 9
Year: 2026
Page: 132-144



 Ali Nabeel Abdulqader ABDULQADER

a*

Muhlis MACİT^b

^a Ataturk University,
alinabil199282@gmail.com

^b Ataturk University,
mmacit@atauni.edu.tr

* Corresponding Author
mmacit@atauni.edu.tr

Citation:

Ali Nabeel Abdulqader ABDULQADER
, Muhlis MACİT , (2026). In Vitro
Evaluation Of Partially Destoned Olive
Cake As An Alternative Roughage Source
In Dairy Cattle Tmr. *ETHABD*, 9, 14532-
14145.

<https://doi.org/10.28949/ethabd.2026491>

Screened by



Except where otherwise noted, content
in this article is licensed under a
Creative Commons 4.0 International
license. Icons by Font Awesome.

IN VITRO EVALUATION OF PARTIALLY DESTONED OLIVE CAKE AS AN ALTERNATIVE ROUGHAGE SOURCE IN DAIRY CATTLE TMR

Extended Abstract

Keywords: Olive cake, dry meadow grass, *in vitro* gas production, methane, feed value, TMR.



Peer-review: External, Independent.

Acknowledgements:

This study was not supported by any institution or funding agency.

Declaration:**1. Originality Declaration:**

This study was produced from the master's thesis entitled "Determination of the Usability of Olive Pomace (Prina) as a Roughage Source in Total Mixed Rations (TMR) for Dairy Cattle by the In Vitro Gas Production Method" by Ali Nabeel Abdulqader ABDULQADER (2023).

2. Author Contributions:

Concept: Ali Nabeel Abdulqader ABDULQADER, Muhlis Macit; **Conceptualization:** Ali Nabeel Abdulqader ABDULQADER, Muhlis Macit; **Literature Search:** Ali Nabeel Abdulqader ABDULQADER; **Data Collection:** Ali Nabeel Abdulqader ABDULQADER; **Data Processing:** Ali Nabeel Abdulqader ABDULQADER; **Analysis:** Ali Nabeel Abdulqader ABDULQADER, Muhlis Macit; **Writing – original draft:** Ali Nabeel Abdulqader ABDULQADER; **Writing – review & editing:** Muhlis Macit.

3. Ethics Committee Approval:

Ethics Committee Approval is not required.

4. Funding/Support:

This study has not received any funding or support.

5. Conflict of Interest Statement:

The author declares that there is no conflict of interest.

6. Sustainable Development Goals: