Potential Nutritive Value and Condensed Tannin Contents of Acorns from Different Oak Species [1]

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Summary

The potential nutritive values of acorns of *Quercus suber*, *Quercus branti*, *Quercus coccifera*, *Quercus cerris* and *Quercus infectoria* were estimated by chemical composition and *in vitro* gas production technique. Acorns collected at least 10 different trees in three experimental plots. There were significant (P<0.001) differences in the chemical composition among acorns obtained from different oak species. Crude protein (CP) contents of acorns ranged from 25.48 to 61.94 g/kg dry matter (DM). Neutral detergent fiber (NDF) contents ranged from 231.4 to 326.3 g/kg DM. Acid detergent fiber (ADF) contents ranged from 155.9 to 215.4 g/kg DM. Starch contents ranged from 600.0 to 681.5 g/kg DM. Polyethylene glycol (PEG) addition significantly (P<0.001) increased the gas production and some estimated parameters of oak acorns. Although there is no significant (P>0.5) differences in the potential gas production of acorn among oak species when incubated in the absence of PEG, there is significant (P<0.001) differences in the potential gas production of acorn among oak species when incubated in the presence of PEG. Although the estimated organic matter (OMD) and metabolisable (ME) contents of acorn for *Q. suber* and *Q. infectoria* were significantly (P<0.001) higher than those for *Q. branti*, *Q. coccifera* and *Q. cerris* when incubated in the absence of PEG, the estimated OMD and ME contents of acorn for *Quercus cerris* and *Q. infectoria* were significantly lower than those for *Q. suber*, *Q. branti* and *Q. coccifera* when incubated in the presence of PEG. The improvement in gas production, OMD and ME in the presence of PEG emphasizes the negative effect of tannins on digestibility. As a conclusion, oak acorns have potential nutritive values for ruminant animals such as sheep and goat since acorns have high starch, OMD and ME but low level of CT contents. However these results obtained in the current study should be supported by in vivo feeding experiments.

Keywords: Oak acorn, Condensed tannin, In vitro gas production Digestibility, Metabolizable energy, Polyethylene glycol

Farklı Meşe Türlerinden Elde Edilen Palamutlarının Potansiyel Besleme Değeri ve Kondense Tanen İçerikleri

Özet

*Quercus suber*, *Quercus branti*, *Quercus coccifera*, *Quercus cerris* ve *Quercus infectoria* meşe palamutlarının potansiyel besleme değerleri, kimsayal kompozisyon ve *in vitro* gaz üretim teknikleri kullanılarak tahmin edilmiştir. Meşe palamutları üç farklı deneme uniteinden en az 10 ağaçtan toplanmıştır. Farklı meşe türünden elde edilen palamutlar arasında önemli farklılıklar olup, ham protein içeriği bir kg'da 25.58 ile 61.94 g arasında, NDF içeriği 231.4 ile 326.3 g arasında, ADF içeriği 155.9 ile 215.4 g arasında, kondense tanen içeriği 7.2 ile 26.7 g arasında, nişasta içeriği 600.0 ile 681.5 g arasında değişmiştir. Polyethylene glycol (PEG) eklenmesi meşe palamutlarından üretilen gaz ve tahmin edilen parametreleri önemli derecede artırmıştır. PEG eklenmeden elde edilen potansiyel gaz üretim deneyi bakımından meşe palamutları arasında önemli farklılıklar olmasına rağmen, PEG eklenmesiyle birlikte potansiyel gaz üretimini bakımından meşe palamutları arasında önemli farklılıklar bulunmuştur. PEG eklenmeden yapılan hesaplamada, *Q. suber* ve *Q. infectoria* palamutunun organik madde sindirimi derecesi (OMSD) ve metabolik enerji (ME) değerleri *Q. branti*, *Q. coccifera* ve *Q. cerris* palamutlarının OMSD ve ME değerlerinden önemli derecede yüksek bulunması rağmen, PEG ekleyerek yapılan hesaplamada, *Q. suber*, *Q. infectoria* palamutunun OMSD ve ME değerleri, *Q. suber*, *Q. branti* ve *Q. coccifera* palamutlarından daha düşük bulunmuştur. PEG katılması ile gaz üretim, OMSD ve ME değerlerindeki meydana gelen iyileşme kondense tanen sindirim üzerindeki negatif etkisini göstermemiştir. Sonuç olarak yüksek nişasta, OMSD ve ME fakat düşük miktar kondense tanen içermesinde dolaylı meşe palamutları koynu keçi gibi ruminant hayvanlar için besleme potansiyeline sahiptir. Bunula birlikte bu çalışmada elde edilen sonuçlar sonraki denemeleriyle desteklenmelidir.

Anahtar sözcükler: Meşe palamudu, Kondense tanen, İn vitro gaz üretimi, Sindirim derecesi, Metabolik enerji, Polyethylene glycol

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INTRODUCTION

Leaves, pods and acorns of shrub and tree are used to meet the requirements of ruminant animals in the most parts of world where few or no alternatives are available. The oak trees from different species produce considerable amount of acorn in the southern of Turkey although exact quantities are very difficult to estimate. There is limited information about the potential nutritive value of acorn from different oak species, although the acorns produced from different oak species were used in ruminant diets on farms where there are no alternative cheap feedstuffs available in the Southern of Turkey. Although the starch contents of acorns are high, the crude protein contents of acorns are considerably low. The starch contents of acorns for several oak species ranged from 56.60 to 59.90% [1]. The crude protein contents of acorn ranged from 3.7 to 7.9% depending on the oak species and maturity stage. Recently in vitro gas production technique has been approved to be as a powerful technique to determine the biological effect of tannin since current analytical techniques do not reflect the biological effects of tannin [2-11]. PEG, a non-nutritive synthetic polymer, has a high affinity to tannins and makes tannins inert by forming tannin PEG complexes [12]. PEG also can also liberate protein from the preformed tannin-protein complexes [13]. The aim of PEG addition was to determine the adverse effect of CT on the gas production and estimated parameters. All incubations were carried out in triplicate. Rumen fluid was obtained from two fistulated sheep fed a daily ration of 800 g alfalfa hay and 250 g concentrates dived into two equal meals at 8:00 and 16:00 h daily. The sheep had free access to water throughout the experiment. Rumen samples was collected before the morning meal in the thermos flaks and taken immediately to the laboratory where it was strained through various layers of cheesecloth and kept at 39°C.

Gas production of acorn samples was determined at 3, 6, 12, 24, 48, 72 and 96 h after incubation. Total gas values were corrected for blank gas production. Cumulative gas production data were fitted to non-linear exponential model as:

\[ Y(t) = A(1 - e^{-ct}) \]

Where \( Y \) is gas production at time \( t \), \( A \) is the potential gas production (ml/200 mg DM), \( c \) is the gas production rate constant (h\(^{-1}\)) and \( t \) is the incubation time (h).

Where,

Metabolizable energy (MJ/kg DM) and OMD (%) values of oak acorn samples were calculated using equations suggested by Menke et al. as follows:

\[ ME (MJ/kg DM) = 2.20 + 0.136 GP + 0.057 CP \quad R^2=0.94 \]
\[ OMD (%) = 14.88 + 0.889 GP + 0.45 CP + 0.00651XA \quad R^2=0.92 \]

Where GP is 24 h net gas production (ml/200 mg DM), CP: Crude protein

XA: Ash content (%)

Data on chemical composition of acorn from oak species was subjected to the one way of ANOVA using GLM of SPSS for windows and were analyzed based on the statistical model. \( Y_{ij} = \mu_{ij} + S_{i} + e_{ij} \). Where, \( Y_{ij} \) = the general mean common for each parameter under investigation. \( S \) the \( i \)th effect of oak species on the observed parameters, \( e \) the standard error term. Data on the in vitro gas production kinetics, OMD and ME contents of oak acorn were subjected to the two way of ANOVA using GLM of SPSS for windows and were analyzed based on the statistical model: \( Y_{ij} = \mu_{ij} + S_{i} + P_{j} + (S \times P)_{ij} + e_{ij} \). Where, \( Y_{ij} \) is the general observation on \( S \)th effect of oak species on the observed parameters and \( P_{j} \) the \( j \)th effect of PEG on the observed parameters. The \( (S \times P)_{ij} \) term represents the interaction effects of species and PEG on gas production.
production and in vitro digestibility, and e; the standard error term common for all observations. Significance between individual means was identified using the Tukey test. Mean differences were considered significant at P<0.05. Standard errors of means were calculated from the residual mean square in the analysis of variance.

RESULTS

The chemical compositions of acorns of Q. suber, Q. branti, Q. coccifera, Q. cerris and Q. infectoria are given in Table 1. There were significant (P<0.001) differences in the chemical composition among acorn obtained from different oak species.

The CP contents of acorn ranged from 25.48 to 61.94 g/kg DM. NDF contents ranged from 231.4 to 326.3 g/kg DM. ADF contents ranged from 155.9 to 215.4 g/kg DM. Starch contents ranged from 600.0 to 681.5 g/kg DM. CT contents ranged from 7.2 to 26.7 g/kg DM. NDF contents ranged from 231.4 to 326.3 g/kg DM. ADF contents ranged from 155.9 to 215.4 g/kg DM. Starch contents ranged from 600.0 to 681.5 g/kg DM.

The CP contents of acorn from Q. suber was significantly (P<0.001) higher than those of acorns from Q. branti, Q. coccifera, Q. cerris and Q. infectoria whereas NDF and ADF contents of acorn from Q. coccifera were significantly (P<0.001) higher than those of acorn from Q. suber, Q. branti, Q. cerris and Q. infectoria. The starch content of acorn from Q. infectoria was significantly (P<0.001) higher than those for Q. suber, Q. branti, and Q. cerris. Condensed tannin content of acorn from Q. coccifera was significantly (P<0.001) higher than that for Q. suber.

The in vitro gas production of oak acorn in the absence and presence of PEG are given in Fig. 1. Gas production in the presence of PEG was considerably higher than those in the absence of PEG irrespective of oak species at all incubation times. However oak species showed variable responses on increase in gas production. Acorn of Q. cerris and Q. infectoria had the highest increase in the gas production at 96 h incubation times.

The gas production, organic matter digestibility (OMD) and metabolisable energy (ME) of acorn from different oak species incubated in the presence and absence of PEG are given in Table 2.

Although there is no significant (P>0.5) differences in the gas production rate and gas production among oak species when incubated in the absence of PEG, there is significant (P<0.001) differences in the gas production rate (c) among oak species when incubated in the presence of PEG. The PEG supplementation significantly increased the gas production rate and gas production. The gas production rate (c) for Q. branti was significantly (P<0.001) higher than those for Q. suber, Q. cerris and Q. infectoria whereas potential gas productions for Q. cerris and Q. infectoria were significantly (P<0.001) higher than those for Q. suber, Q. cerris and Q. coccifera.

There were significant (P<0.001) differences in the estimated OMD and ME contents of acorn incubated in the presence and absence of PEG among oak species. The species and PEG supplementation had a significant (P<0.001) effect on the estimated OMD and ME contents.

Although the estimated OMD and ME contents of acorn for Q. suber and Q. infectoria were significantly higher than those for Q. branti, Q. coccifera and Q. cerris when incubated in the absence of PEG, the estimated OMD and ME contents for Q. cerris and Q. infectoria were significantly lower than those for Q. suber, Q. branti and Q. coccifera when incubated in the presence of PEG.

Two-way anova revealed significant interaction between PEG treatment and oak species for estimated parameters such as gas production rate, potential gas productions, OMD and ME contents.

DISCUSSION

The species had a significant (P<0.001) effect on the chemical composition of acorn. There is significant (P<0.001) variation in the chemical composition of acorn. The CP and

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Oak Species</th>
<th>SEM</th>
<th>Sig.</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Q. suber</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q. branti</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Q. coccifera</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Q. cerris</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Q. infectoria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>916.1**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>CA</td>
<td>21.2**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>CP</td>
<td>61.9**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>NDF</td>
<td>236.5**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>ADF</td>
<td>155.9**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>Starch</td>
<td>600.0**</td>
<td></td>
<td>***</td>
</tr>
<tr>
<td>CT</td>
<td>20.9**</td>
<td></td>
<td>*</td>
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</tbody>
</table>

*Row means with common superscript did not differ (P>0.05); SEM: Standard error of mean, DM: Dry matter, CA: Crude ash (g/kg DM), CP: Crude protein (g/kg DM), NDF: Neutral detergent fibre (g/kg DM), ADF: Acid detergent fibre (g/kg DM), CT: Condensed tannin (g/kg DM), Sig: significance level, * P<0.05, *** P<0.001
NDF contents of acorn from *Q. coccifera* obtained in the current study were considerably lower than those obtained by Moujahed et al.\(^6\), whereas ADF content of acorn from *Q. coccifera* was higher than that reported by Moujahed et al.\(^6\). The CP, NDF, ADF and CT contents of *Q. suber* were considerably lower than those reported by Baubaker et al.\(^22\). The differences among studies are possibly associated with differences in production site and stage of maturity of acorn. Baubaker et al.\(^7\) suggested that some variation in the chemical composition of acorn can be expected due to variation in production site, *Quercus* species and stage of maturity. On the other hand, Moujahed et al.\(^24\) showed that the chemical composition of acorn from *Q. coccifera* was significantly changed with maturity. Especially cell wall (NDF and ADF) contents of acorn decreased with increasing maturity.

**Fig 1.** The effect of polyethylene glycol (PEG) on the gas production of oak acorn from different species

**Şekil 1.** Polyethylene glycol’ün farklı meşe türlerinden elde edilen palamutların gaz üretimine etkisi
It seems to be likely that oak acorn studied in this experiment will not meet the CP requirements of ewes for maintenance and lactation since the CP content of oak acorn studied in this experiment lower than those requested for maintenance and lactation of sheep. El-Shatnawi and Mohawesh\(^2\) reported that ewes require 7-9% CP for maintenance and lactation of sheep. On the other hand, Moujahed et al.\(^2\) also showed that CP requirements of Q. coccifera acorns studied in this experiment lower than those requested for maintenance and lactation of ewes. Therefore, the increase in the CP content of oak acorns could not be limited by low levels of condensed tannins which are ranged from 6.3% to 26.7% with increasing maturity. This possibly due to differences in the amount or chemical composition of the tannins acorns contained.

Significant interaction between species and PEG supplementation for the estimated gas production kinetics, OMD and ME values (Table 2), indicating that acorns did not show similar response to PEG supplementation during in vitro incubation study. The increase for gas production rate of acorn of Q. branti in the presence of PEG was approximately 4.2% whereas the increase for gas production rate of acorn of Q. suber in the presence of PEG was approximately 24.1% whereas the increase for gas production rate of acorn of Q. coccifera was approximately 9.44%. This possibly due to differences in the amount or chemical composition of the tannins acorns contained.

The acorns from different oak species seem to be very energetic alternative sources due to high starch contents and would be used to some extent in sheep and goats...

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Table 2. Effect of polyethylene glycol (PEG) and species on the gas production, organic matter digestibility (OMD) and metabolisable energy (ME) of acorns

<table>
<thead>
<tr>
<th>Species</th>
<th>ME (%)</th>
<th>OMD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. suber</td>
<td>61.73</td>
<td>67.56</td>
</tr>
<tr>
<td>Q. branti</td>
<td>68.93</td>
<td>73.48</td>
</tr>
<tr>
<td>Q. coccifera</td>
<td>69.87</td>
<td>73.30</td>
</tr>
<tr>
<td>Q. cerris</td>
<td>65.81</td>
<td>70.59</td>
</tr>
<tr>
<td>Q. infectoria</td>
<td>63.08</td>
<td>69.90</td>
</tr>
</tbody>
</table>

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It was also reported that PEG is also able to liberate protein and makes tannins inert by forming tannin PEG complexes. Nutritive synthetic polymer, has a high affinity to tannins due to an increase in the available nutrients to rumen microorganisms, especially carbohydrates and nitrogen contents of oak acorn. Makkar et al.\(^1\) suggested that PEG, a non-nutritive synthetic polymer, has a high affinity to tannins and makes tannins inert by forming tannin PEG complexes. It was also reported that PEG is also able to liberate protein from the preformed tannin-protein complexes.\(^1\)

The potential gas production (A) and gas production rate (c) of Q. coccifera were comparable with findings of Rubanza et al.\(^2\) and Karabulut et al.\(^3\) who found that PEG supplementation increased the gas production and estimated parameters such as ME and OMD values. The increase in the gas production and estimated parameters in the presence of PEG emphasizes the negative effect of tannins on digestibility of oak acorn. The increase in the gas production, their kinetics, OMD and ME in the presence of PEG is possibly due to an increase in the available nutrients to rumen microorganisms, especially carbohydrates and nitrogen contents of oak acorn. It was also reported that PEG is also able to liberate protein from the preformed tannin-protein complexes.\(^4\)

Although oak acorn selected in this study had low CT contents, PEG supplementation resulted in increase in gas production and some estimated parameters. These results obtained in current study are consistent with findings of Rubanza et al.\(^4\) and Karabulut et al.\(^3\) who found that PEG supplementation increased the gas production and estimated parameters such as ME and OMD values. The increase in the gas production, their kinetics, OMD and ME in the presence of PEG is possibly due to an increase in the available nutrients to rumen microorganisms, especially carbohydrates and nitrogen contents of oak acorn. It was also reported that PEG is also able to liberate protein from the preformed tannin-protein complexes.\(^1\)

The acorns from different oak species seem to be very energetic alternative sources due to high starch contents and would be used to some extent in sheep and goats.
diets where there is food shortage. However the substitution rate of acorn for barley is very important. Jassim et al. suggested that substitution of acorn for barley at a maximum level of 25% would be economically advantageous. High substitution rate of acorn for barley resulted in decreased daily gain due to the decreased digestibility of nutrients.

As a conclusion, oak acorns have potential nutritive values for ruminant animals such as sheep and goat since acorns have high starch, OMD and ME but low level of CT contents. However these results obtained in the current study should be supported by in vivo feeding experiments.

REFERENCES