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RESEARCH ARTICLE

Determination of Potential Nutritive Value of Exotic Tree Leaves in Turkey

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Summary

The aim of this study was to determine the effects of plant species on the potential nutritive value of introduced tree leaves using the chemical composition and *in vitro* gas production. Gas productions of the introduced tree leaves were determined at 3, 6, 12, 24, 48, 72 and 96 h incubation times and their gas production kinetics were described using the equation $y=A(1-exp^{-ct})$. Plant species had a significant effect on the chemical composition, *in vitro* gas production, metabolisable energy (ME) and organic matter digestibility (OMD) of the introduced tree leaves. The crude protein content of leaves ranged from 14.16 to 21.92%. The crude protein content of leaves from *Robinia poseudoecacia umbraculifera* was significantly (P<0.001) higher than those of other legume trees. The NDF and ADF content of legume trees ranged from 30.42 to 41.55 and 27.81 to 28.06% respectively. NDF content of leaves from *Gladitsia triacanthos* was significantly (P<0.05) higher than those of other legume trees. Although the gas production rate (c) of leaves *Albiza julibrissin* was significantly (P<0.05) higher than those of *Gladitsia triacanthos* and *Robinia poseudoecacia umbraculifera*. The potential gas production of *Albiza julibrissin* was significantly higher than those for *Gladitsia triacanthos* and *Robinia poseudoecacia*. The ME and OMD contents of introduced tree leaves ranged from 9.49 to 10.36 MJ/kg DM and from 64.42 to 70.3% respectively. In conclusion, the species had a significant effect on the potential nutritive value of introduced legume tree leaves. However the tree leaves studied in the current study would be effective protein resource for ruminant animals and may correct the deficient nitrogen in basal roughages with low protein during critical period of year when feed shortage occurred. However leaves obtained from *Robinia pseudoecacia umbraculifera, Gladitsia triacanthos,* and *Robinia psedoecacia* should be supplemented with polyethylene glycol or treated with alkali to reduce the detrimental effect of condensed tannin. Condensed tannin (CT) contents of legume trees ranged from 1.70 to 18.35%.

Keywords: *Exotic plants, Chemical composition, Metabolisable energy, Organic matter digestibility, Condensed tannin*

Türkiye'deki Bazı Egzotik Ağaç Yapraklarının Potansiyel Besleme Değerinin Belirlenmesi

Özet

Bu çalışmanın amacı, bazı egzotik ağaç yapraklarının potansiyel besleme değerlerini kimyasal kompozisyon ve *in vitro* gaz üretim tekniği kullanarak belirlemektir. Egzotik ağaç yapraklarının *in vitro* gaz ölçümleri fermantasyonun 3, 6, 12, 24, 48, 72 ve 96'ıncı saatlerinde yapılmıştır. Gaz üretimine ait parametreler $y=A(1-exp^{-ct})$ fonksiyonu ile belirlenmiştir. Egzotik ağaç yaprakların kimyasal kompozisyonu, in vitro gaz üretimi, metabolik enerji (ME) içeriği, organik madde sindirim derecesi (OMSD) üzerine önemli etkisinin olduğu saptanmıştır. Egzotik ağaç yaprakların protein içeriği %14.16 ile 21.92 arasında değişmiştir. Top akasya *(Robinia pseudoecacia umbraculifera)* yaprağının protein içeriği ise diğer ağaçların yapraklarının protein içeriğinden daha yüksek bulunmuştur. Egzotik ağaç yapraklarının NDF ve ADF içerikleri sırasıyla %30.42 ile 41.55 ve 27.81 ile 28.06 arasında değişmiştir. Gladiçya ağaç yaprağının NDF içeriği diğer ağaç yapraklarının NDF içeriğinden daha yüksek saptanmıştır. Gülibrişim *(Albizia julibrissin)* ağaç yaprağının gaz üretim hızı, gladiçya *(Gladitsia triacanthos)* ve top akasya (Robinia pseudoecacia umbraculifera) ağacı yaprağından önemli derecede daha yüksek bulunmasına rağmen, potansiyel gaz üretim miktarı yalnızca gladiçya ve adi akasya yaprağından daha yüksek bulunmuştur. Metabolik enerji (ME) ve organik madde sindirim derecesi (OMS) sırasıyla 9.49 ile 10.36 MJ/kg KM ve %64.42 ile 70.3 arasında değişmiştir (P<0.001). Sonuç olarak, ağaç yapraklarının potansiyel besleme değeri üzerine ağaç türünün önemli etkisi olmuştur. Bununla birlikte, bu çalışmada yer alan ağaç yaprakları ruminant hayvanların beslenmesinde kullanılabilecek etkin bir protein kaynağı olabilir. Kritik zamanlarda düşük protein içerikli rasyonların protein açığını kapatmada kullanılabilir. Bununla birlikte, kondense tanenin olumsuz etkisini azaltmak için top akasya, gladiçya ve yalancı akasya *(Robinia psedoecacia)* yaprakları polietilen glikol veya alkali ile muamele edilerek verilmelidir. Egzotik ağaç yapraklarının kondense tanen içerikleri %1.70 ile 18.35 arasında değişmiştir.

Anahtar sözcükler: *Egzotik ağaçlar, Kimyasal kompozisyon, Metabolik enerji, Organik madde sindirim derecesi, Kondense tanen*

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INTRODUCTION

It was well established that tree leaves are important components of diets for goats, cattle, deer, game and sheep [1,2] and have an important role in nutrition of herbivores in areas where few or no alternatives are available [3,4]. Some legume trees such *Robinia pseudoecacia umbraculifera; Gladitsia triacanthos, Albizia julibrissin* and *Robinia psedoecacia* were well adapted to the most parts of Turkey. Recently there has been increasing interest in using the leaves of these exotic trees during dry seasons when there is a feed shortage.

It was reported that tree legumes with their high crude protein contents DM have potential as CP supplements in ruminant rations. However condensed tannin content in tree leaves is the primary factors affecting the utilization of CP in leaves in ruminant diets when fed at high levels, due to their adverse effects on feed digestibility and nutrient availability [5]. Condensed tannin in leaves can form complexes with proteins and carbohydrates and reduce the ruminant availability [6]. Condensed tannin may also results in decrease the proteolysis and ammonia production in the rumen. As a result of this the microbial activity may be decreased [7,8].

Chemical compositions, in combination with *in vitro* gas production, OMD and ME content were widely used to determine potential nutritive values of forages [9-12]. Although the most of the native trees and shrubs were evaluated in terms of chemical composition, *in vitro* and *in situ* technique [13-15] there is limited information on the chemical composition and nutritive value of exotic tree leaves in Turkey. Therefore the aim of the current study was to determine potential nutritive value of the introduced tree leaves by chemical composition and *in vitro* gas production.

MATERIAL and METHODS

Tree Leaves

Leaves from *Robinia pseudoecacia umbraculifera, Gladitsia triacanthos, Albiza julibrissin* and *Robinia psedoecacia* were hand harvested from at least 10 different trees in dry season (July, 2010) in the vicinity of city, Bursa, in the west of Turkey. The harvested leaves pooled and oven dried at 60°C.

Chemical Analysis

Dry matter (DM) was determined by drying the samples at 105°C overnight while total ash was determined by igniting the samples in muffle furnace at 525°C for 8 h. Nitrogen (N) content was measured by the Kjeldahl method [16]. Crude protein of tree leaves was calculated as N x 6.25. Cell wall contents (NDF and ADF) of tree leaves were determined using the method described by Van Soest et al.[17]. Condensed tannin of tree leaves was determined by butanol-HCI method as described by Makkar et al.[18]. All chemical analyses were carried out in triplicate.

In vitro Gas Production

Grounded tree leave samples (0.2 g DM) were incubated *in vitro* with diluted rumen fluid (10 ml rumen fluid + 20 ml culture medium) in calibrated glass syringes of 100 ml following the procedures of Menke and Steingass [19]. All incubations were carried out in triplicate. Rumen fluid was obtained using stomach tube from two lactating and pregnant cows fed a daily ration containing 20 kg maize silage and 10 kg concentrates (%18 CP and 2750 kcal ME/kg) The cows had free access to water throughout the experiment. Rumen samples were collected before the morning feeding in the thermos flaks and taken immediately to the laboratory where it was strained through 4 layers of cheesecloth and kept at 39°C.

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

$$Y = A\,(1-\exp^{-ct})$$

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).

ME (MJ/kg DM) content of tree leaves was calculated using equation of Menke et al.[20] as follows:

$$\text{ME (MJ/kg DM)} = 2.20 + 0.136\ \text{GP} + 0.057\ \text{CP}$$

where GP = 24 h net gas production (ml/200 mg); CP = Crude protein

Organic matter digestibility (%) of tree leaves was calculated using equation of Menke et al.[20] as follows:

$$\text{OMD (\%)} = 14.88 + 0.889\text{GP} + 0.45\text{CP} + 0.0651\ \text{XA}$$

where XA: ash content (%)

One-way analysis of variance (ANOVA) was used to determine the effect of plant species on chemical composition, gas production kinetics, and some estimated parameters such as ME and OMD of introduced tree leaves. Significance between individual means was identified using the Tukey's multiple range tests. Mean differences were considered significant at ($P<0.05$). A simple correlation analysis was used to establish the relationship between chemical composition and *in vitro* gas production kinetics or estimated parameters [21].

RESULTS

The effect of plant species on the chemical composition of leaves is given in *Table 1*. The effect of species on *in vitro* gas production of leaves is given in *Fig. 1*. The effect of plant species on *in vitro* gas production kinetics, ME and OMD is given in *Table 2* and correlation coefficients of chemical composition and *in vitro* gas production kinetics or estimated parameters are given in *Table 3*.

Table 1. *Chemical composition of some introduced tree leaves in Turkey*
Tablo 1. *Türkiye'de yetişen bazı ağaç yapraklarının kimyasal bileşimleri, %*

Chemical Composition	Tree Leaves				SEM	P
	R. pseudoecacia umbraculifera	*Gladitsia triacanthos*	*Albiza julibrissin*	*Robinia pseudoecacia*		
DM	42.65	42.93	40.29	42.94	1.34	NS
Ash	10.53^{d}	11.83^{b}	11.03^{c}	13.00^{a}	0.08	***
CP	21.92^{a}	14.16^{d}	17.20^{b}	16.33^{c}	0.20	***
NDF	34.21^{c}	41.55^{a}	40.33^{b}	30.42^{d}	0.30	***
ADF	28.06^{c}	31.28^{a}	29.52^{b}	27.81^{c}	0.38	***
CT	11.54^{b}	16.11^{ab}	4.13^{c}	18.35^{a}	1.70	***

*a,b,c Row means with common superscripts do not differ (P>0.05); **s.e.m:** standard error mean, **Sig.:** significance level, **DM:** Dry matter %, **CP:** Crude protein, **NDF:** Neutral detergent fiber, **ADF:** Acid detergent fiber, **CT:** Condensed tannin, **NS:** Non-significant, *** P<0.001*

Table 2. *In vitro gas production kinetics, metabolisable energy and organic matter digestibility of some introduced tree leaves in Turkey*
Tablo 2. *Türkiye'de yetişen bazı ağaç yapraklarının in vitro gaz üretimi kinetikleri, metabolik enerji ve organik madde sindirimi*

Parameter	Tree Leaves				SEM	Sig.
	R. pseudoecacia umbraculifera	*Gladitsia triacanthos*	*Albiza julibrissin*	*Robinia pseudoecacia*		
c	0.068^{c}	0.072^{b}	0.083^{a}	0.077^{ab}	0.002	***
A	63.22^{ab}	60.76^{b}	64.73^{a}	60.77^{b}	0.817	***
ME	10.15^{a}	9.49^{b}	10.36^{a}	9.63^{b}	0.124	***
OMD	68.22^{a}	64.42^{b}	70.31^{a}	65.60^{b}	0.817	***

*a,b,c Row means with common superscripts do not differ (P>0.05); **s.e.m.:** standard error mean; **Sig.:** significance level;, **c:** gas production rate (%), **A:** potential gas production (mL), **ME:** Metabolisable energy (MJ /Kg DM), **OMD:** Organic matter digestibility %, *** P<0.001*

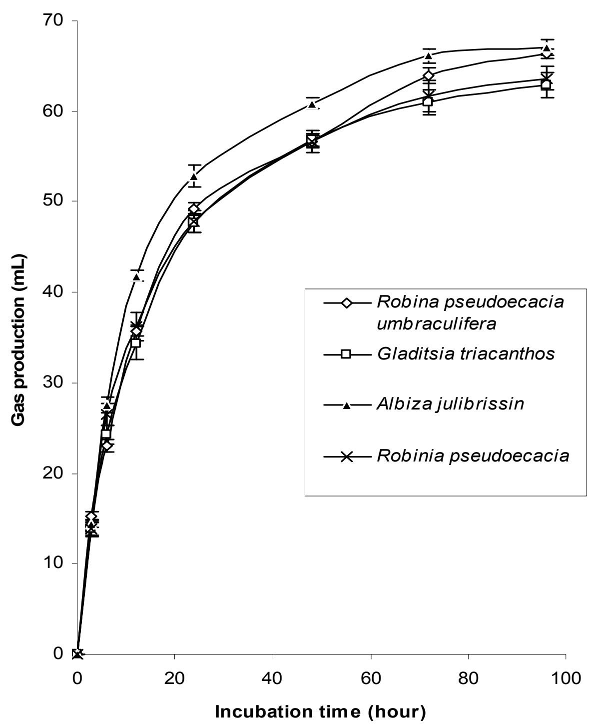

Fig 1. *In vitro* gas production of some introduced tree leaves in Turkey
Şekil 1. Türkiye 'de yetişen bazı ağaç yapraklarının *in vitro* gaz üretimleri

Table 3. *Correlation coefficient of chemical composition and in vitro gas production kinetics or estimated parameters.*
Tablo 3. *İn vitro gaz üretim kinetikleri ile kimyasal kompozisyonlar arasındaki korelasyonlar*

Parameter	c	A	OMD	ME
CP	-0.324^{NS}	0.476^{NS}	0.672**	0.626**
NDF	0.166^{NS}	0.253^{NS}	0.062^{NS}	0.110^{NS}
ADF	0.046^{NS}	-0.063^{NS}	-0.272^{NS}	-0.225^{NS}
CT	-0455^{NS}	-0.860***	-0.822***	-0.843***

CP:** Crude protein, **NDF:** Neutral detergent fiber, **ADF:** Acid detergent fiber, **CT:** Condensed tannin, **c:** gas production rate (%); **A:** potential gas production (mL), **ME:** Metabolisable energy (MJ /Kg DM, **OMD:** Organic matter digestibility %, **NS:** Non-significant, ** P<0.01, P<0.001*

DISCUSSION

Chemical Composition

The effect of species on chemical composition of leaves is given in *Table 1*. Except for dry matter content, the species had a significant (P<0.001) effect on chemical composition. The crude protein content ranged from 14.16 to 21.92%. The crude protein content of leaves from *Robinia poseudoecacia umbraculifera* was significantly (P<0.001) higher than those of other legume trees. Rubanza et al.[22] suggested that differences in crude protein content between different tree species could be mainly to variations in factors controlling protein accumulation in forages during growth process.

Although the crude protein content of *Robinia poseudoecacia* was comparable with those reported by Chen et al.[23], was considerable lower than the value reported by Rakesh et al.[24] and Burner et al.[25]. On the other hand the crude protein content of *Albizia julibrissin* was similar to the content reported by Burner et al.[25]. Although CP and ADF contents of *Gladitsia triacanthos* were comparable with those reported by Buergler et al.[25] NDF content was considerably lower than that reported by Buergler et al.[26].

These differences between various different studies in nutrient composition was possibly due to differences in harvesting time and climatic condition of tree species. Buergler et al.[26] showed that chemical compositions were significantly influenced by harvesting time, species and tree density.

The NDF and ADF content of legume trees ranged from 30.42 to 41.55 and from 27.81 to 28.06%, respectively. NDF content of leaves from *Gladitsia triacanthos* was significantly higher than those of other legume trees. The tree leaves studied in the current study can be considered as good quality roughage sources since fibrous feeds with NDF content of less than 45% of DM were classified as high quality roughage feeds [27]. The NDF and ADF contents of *Robinia poseudoecacia* were considerably higher than that reported by Chen et al.[23] whereas NDF and ADF content of *Robinia poseudoecacia* were considerably lower than those reported by Rakesh et al.[24].

CT content of introduced tree leaves ranged from 4.13 to 18.35% of dry matter. CT content of *Albiza julibrissin* was significantly lower than those of other introduced tree leaves.

Van Soest [28] indicated that crude protein content of browse species should be higher than the minimum level of 7-8% of DM for optimum rumen function and feed intake in ruminant animals. In the current study, the all legume species provided the leaves with crude protein which is higher than that minimum level of 7-8% of DM. Therefore these tree leaves from different legume species may form potential feed resources mainly as protein supplements to ruminant animals and may correct the deficient nitrogen in basal roughages with low protein during critical period of year when feed shortage occurred. However the efficiency of protein utilization in tree leaves is dependent on the soluble phenolic compounds such as tannins and insoluble proanthocyanidins [29].

High level of CT (more than 5% of DM) limited the nutrients utilization in ration through chemical formations. Tannin also inhibits the microbial activity and enzymes [30-35]. However in ruminants, dietary condensed tannins (2-3% of DM) were shown to have beneficial effects because they reduce the protein degradation in the rumen by formation of a protein-tannin complex [36].

Albiza julibrissin had lower CT contents than 5% of DM. Therefore optimal utilization of CP in leaves obtained from *Albiza julibrissin* could not be restricted by CT. On the other hand CT contents of other introduced tree leaves were higher than 5% of DM. Therefore optimal utilization of CP in leaves obtained from other introduced tree leaves may be hampered by CT. Therefore leaves obtained from *Robinia pseudoecacia umbraculifera, Gladitsia triacanthos,* and *Robinia psedoecacia* should be supplemented with polyethylene glycol (PEG) or treated with alkali to reduce the detrimental effect of condensed tannin.

***In vitro* Gas Production and Estimated Parameters**

The effect of plant species on Egzotik ağaç yapraklarının *in vitro* gas production of leaves is given in *Fig. 1*. The effect of plant species on *in vitro* gas production kinetics, ME and OMD of leaves of the introduced legume trees is given in *Table 2*. The species had a significant ($P<0.001$) effect on *in vitro* gas production kinetics, ME and OMD. Although the gas production rate of leaves *Albiza julibrissin* was significantly higher than those of *Gladitsia triacanthos* and *Robinia poseudoecacia umbraculifera*. The potential gas production of *Albiza julibrissin* was significantly higher than those for *Gladitsia triacanthos* and *Robinia poseudoecacia*.

The plant species had also significant ($P<0.001$) effect on the ME and OMD contents. The ME and OMD contents of introduced tree leaves ranged from 9.49 to 10.36 MJ/kg DM and 64.42 to 70.3% respectively. Although the OMD of *Albiza julibrissin* was comparable with that reported by Burner et al.[25], the OMD of *Robinia poseudoecacia* was considerably lower than that reported by Burner et al.[25].

The correlation coefficient of chemical composition and *in vitro* gas production kinetics or estimated parameters is given in *Table 3*. Although the CP content was positively correlated with OMD and ME content of tree leaves, CT content is negatively correlated with potential gas production, OMD and ME content of leaves. These results are consistent with finding of Kamalak [37] who suggested that the increase in CT content decreased the ME and OMD contents of leaves from *Glycyrrhiza glabra*.

The species had a significant effect on potential nutritive value of introduced legume tree leaves. The tree leaves studied in the current study would be effective protein supplements for ruminant animals and may correct the deficient nitrogen in basal roughages with low protein during critical period of year when feed shortage occurred. However leaves obtained from *Robinia pseudoecacia umbraculifera, Gladitsia triacanthos,* and *Robinia psedoecacia* should be supplemented with polyethylene glycol (PEG) or treated with alkali to reduce the detrimental effect of condensed tannin.

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