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Effect of Maturity Stages on Potantial Nutritive Value of *Rheum ribes* L.

Olgunlaşma Döneminin *Rheum ribes* L.'nin Potansiyel Besleme Değerine Etkisi

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Abstract: The purpose of the current work was to designate the effect of maturity stages potential nutritive value, the chemical composition, condensed tannin (CT), gas production (GP), methane production, metabolizable energy (ME), and organic matter digestibility (OMD) of *Rheum ribes* L. Maturity stages significantly affected (P<0.05) the chemical composition, CT, GP, methane production, ME and OMD of *Rheum ribes* L. Dry matter (DM), crude ash (CA), crude protein (CP), ether extract (EE), CT, neutral detergent fiber (NDF) and acid detergent fiber (ADF) of *Rheum ribes* L. ranged from 92.73-98.64%, 6.11-14.15%, 8.81-19.12%, 1.94-3.04%, 10.47-14.72%, 36.99-53.98% and 24.88-37.63% respectively. Gas production and methane production of *Rheum ribes* L. at 24 ranged from 29.73-40.60 ml and 2.63-5.50 ml respectively. ME and OMD of *Rheum ribes* L. ranged from 6.97-9.87 MJ kg^{-1} KM and 45.68-60.02% respectively. To sum up, maturity stages is a significant point on the nutritive value of *Rheum ribes* L. Nutritive value especially CP, ME and OMD of *Rheum ribes* L. decreased with advancing maturity. GP, ME and OMD were significant and negatively correlated with ADF and NDF contents, whereas positively correlated with CP. Moreover in vivo studies are needed to determine the effect of *Rheum ribes* L. on the feed intake and performance of ruminant animals.

Keywords: *Rheum ribes* L., nutritive value, condansed tannin, methane production

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Öz: Bu çalışmanın amacı *Rheum ribes* L. 'nin farklı olgunlaşma dönemlerinin kimyasal bileşiminine, kondanse tanen (KT) içeriğine, gaz ve metan üretimine, metabolik enerji (ME) ve organik madde sindirim derecesine (OMSD) etkisinin belirlenmesidir. Olgunlaşma dönemi kimyasal bileşimi, KT içeriğini, gaz ve metan üretimini, ME ve OMSD önemli derecede etkilemiştir (P<0.05). *Rheum ribes* L.'nin kuru madde (KM), ham kül (HK), ham protein (HP), ham yağ (HY), KT, asit çözücülerde çözünmeyen lifli bileşikler (ADF), nötr çözücülerde çözünmeyen lifli bileşikleri (NDF) sırasıyla 92.73-98.64%, 6.11-14.15%, 8.81-19.12%, 1.94-3.04%, 10.47-14.72%, 36.99-53.98% and 24.88-37.63% aralıklarında belirlenmiştir. Rheum ribes L.'nin 24 saatlik gaz üretimi, metan üretimi 29.73-40.60 ml ve 2.63-5.50 ml aralığında belirlenmiştir. ME ve OMSD 6.97-9.87 MJ kg^{-1} KM ve 45.68-60.02% aralığında belirlenmiştir. Özet olarak olgunlaşma dönemi *Rheum ribes* L.'nin besleme değerini önemli ölçide etkilemiştir. Rheum ribes L. 'nin özellikle HP, ME, OMSD olgunlaşma dönemi ilerledikçe azalmıştır. *Rheum ribes* L.'nin gaz üretimi, ME ve OMSD, ADF ve NDF içeriği ile önemli ve negatif korelasyon göstermiş, ham protein içeriği ile pozitif korelasyon sergilemiştir. Ek olarak *Rheum ribes* L.'nin ruminant hayvanların performansı ve besleme değerinin belirlenebilmesi için in vivo çalışmalara da ihtiyaç duyulmaktadır.

Anahtar Kelimeler: *Rheum ribes* L., besleme değeri, kondanse tanen, metan üretimi

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INTRODUCTION

Forages have an important role in ruminant animal nutrition with the potein, mineral and energy they provide. At the same time, these forages are a source of fiber for animals with chewing and rumination. There are many factors that affect the nutritional value of forages. Although the effect of the maturation period, which is one of them, on the chemical composition, metabolic energy content and digestion degree of plants has been revealed by some researchers, there are many more plants waiting to be investigated in natural pastures (Atalay and Kamalak, 2019; Kaplan et al., 2016; Kurt and Kamalak, 2020) *Rheum ribes* L. has several different local Turkish names such as: ısgın, ucgun, dag muzu, ribes, revas. *Rheum ribes* L. that is belonging to *Polygonaceae*, is a perennial wild plant that is of medical importance as flowers shoots and stalks can be consumed as vegetables. It has been reported that the only species grown in our country belonging to the genus *Rheum* is *Rheum ribes* L. (Cullen, 1996; Tuncer and Günsan, 2017). In the high plateaus, in the season when the snow starts to melt, it has a 40 cm tall inflorescence stem that rises from the large coarse leaves in the form of elephant ear, 2-5 long-stalked, kidney-shaped leaves with toothed edges, small flowers and a well-developed taproot (Baytop, 1984). It grows naturally in the Eastern Anatolia Region, where Muş is located, and is collected from nature in the spring and summer months and consumed (Muzuroğlu et al., 2000). In different regions, different plant parts are evaluated both nutritionally and medicinally (Chang et al., 2014; Çakılcıoğlu and Türkoğlu, 2007; Hu et al.,2014; Kaval et al.,2014; Meral, 2017). In our country, there are studies on the nutrient content and medical importance of the ray plant, and no study has been found in which the animal nutrition value is determined by using the in vitro gas production technique. Some screening assays have been conducted in recent years to try to identify plant species with potential antimethanogenic activity (García- González et al., 2008; Soliva et al., 2008).

In the study, it was aimed to determine the chemical composition and anti-methanogenic effect of the *Rheum ribes* L., which is widely found in the natural flora of Muş province, at different maturation periods (pre-flowering, flowering, seedling).

MATERIAL AND METHOD

Rheum ribes L. plants were harvested from plots established in the experiment unit of native pastures at 3 different maturation periods (pre-flowering, flowering and seedling stages) in Mus, Turkey, in April-May, 2021. The collected samples were dried in the shade after their dry matter was determined, ground to pass through a 1 mm sieve, and made ready for chemical analysis and in vitro gas production. Dry matter (DM) was determined by drying the samples at 105˚C overnight and ash by igniting the samples in muffle furnace at 525˚C for 8 h. Nitrogen (N) content was measured by the Kjeldahl method (AOAC, 1990). Crude protein was calculated as N X 6.25., EE content of Rheum ribes L. determined by AOAC (1990), ADF and NDF were determined according to the method reported by Van Soest et al. (1991). CT concentration was determined by described by Makkar et al. (1995). *In vitro* gas production technique was used to determine the TG production of *Rheum ribes* L. samples (Menke et al., 1979). Rumen fluid was immediately taken from sheep slaughtered in the Kahramanmaraş animal market and placed in a thermos, and brought to the laboratory quickly so that microorganism activitycould continue. Approximately 0.200 gram air dried samples of Rheum ribes L. samples was weighed into calibrated glass syringes which were prewarmed at 39˚ C. Then 30 mL rumen fluid-buffer mixture was transferred into each syringe. The glass syringes containing samples and rumen fluid-buffer mixture were placed in a water bath at 39˚ C. Gas production was measured at 24 h after incubation and corrected for blank and hay standard. The gases obtained as a result of the incubation were determined by transferring them to the Infrared Methane Analyzer (Sensor Europe GmbH, Erkrath, Germany) with plastic syringes to determine the methane percentages (Goel et al. 2008). The methane gas production amounts of the samples were calculated using the formula given below.

$$\text{Methane production (ml)} = \text{Total gas production (ml) X Percentage of Methane (\%)} \quad (1)$$

ME and OMD of *Rheum ribes* L. were determined according to the following equations (Menke and Steingass, 1988).

$$\text{ME (Mj kg}^{-1}\text{ DM)} = 1.06 + 0.1570\text{GP} + 0.084\text{CP} + 0.220\text{EE} - 0.081\text{CA} \quad (2)$$

$$\text{OMD (\%)} = 28.49 + 0.7967\text{GP} + 0.325\text{CP} \quad (3)$$

GP= Net gas production at 24 h incubation time

The data obtained in the study were evaluated statistically (Tukey 5%) using one-way analysis of variance (One-way ANOVA).

RESULTS AND DISCUSSION

Effects of maturity stage on the chemical composition and condanse tanen of *Rheum ribes* L. plants are summarized in Table1. Changes (P<0.05) were observed for chemical composition and condanse tanen in terms of maturity stages. The CP content of *Rheum ribes* L. ranged from 8.81-19.12% and decreased with increased maturity. CP content *Rheum ribes* L. harvested at the preflowering stage was significantly higher than those of the flowering and seedling stages. This decrease in protein content is due to the decrease in protein concentration in stems and leaves as maturation progresses (Buxton, 1996). Such result is in agreement with findings of similar experiment (Atalay and Kamalak 2019; Aydın et al., 2007; Canbolat, 2012; Giray, 2019; Kamalak et al., 2011; Kaplan et al., 2016; Kurt and Kamalak, 2020). Özcan et al. (2007) determined the HP content of the *Rheum ribes* L. as 5.45-6.31%, Andiç et al. (2009), determined the HP content of the *Rheum ribes* L. as 1.07-1.56%, and Tunçtürk and Çelen (2017) determined the HP content of the *Rheum ribes* L. as 21.69%. All these variations might have resulted in ecological conditions, maturity stages, plant parts. It has been reported that for optimum rumen fermentation and feed consumption in ruminants, the HP content of the feeds should be at least 7-8% (Van Soest, 1994). In this case, the HP content of the *Rheum ribes* L. was found to be appropriate in three maturity stages.

The CA content of *Rheum ribes* L. varied between 6.11-14.15 %, and it was found to be significantly higher during the flowering period compared to the pre-flowering and seedling stages (P<0.05). Ozcan et al. (2007) reported CA content *Rheum ribes* L. as between 7.74-9.69%, Tuncturk ve Celen (2017) as 7%. Such results support the our current findings. The EE content of *Rheum ribes* L. ranged from 1.94-3.04%. The highest EE content *Rheum ribes* L. was determined during the flowering period. Ozcan et al. (2007) reported EE content *Rheum ribes* L. as between 1.90-3.60%. Such results support our current findings.

The ADF and NDF content of *Rheum ribes* L. ranged from 24.88-37.63%, 36.99-53.98% respectively. It was determined that ADF and NDF content increased from pre-flowering to the seedling period. Similarly, it has been reported in various studies that ADF and NDF content with advancing maturity were significantly increased (Atalay and Kamalak, 2019; Aydın et al., 2007; Canbolat, 2012; Giray, 2019; Kamalak ve ark., 2005a, 2005b; Kamalak and Canbolat 2010; Kamalak et al., 2011; Kaplan et al., 2016; Kurt and Kamalak, 2020). The CT content of *Rheum ribes* L. ranged from 10.47-14.72% and decreased with increased maturity. It has been reported that the low level of condensed tannin in the feed (1-4% in dry matter) has a beneficial effect as it prevents the excessive breakdown of proteins in the rumen, while the high amount of grains (5% and above in dry matter) affects the performance of the animal negatively by limiting feed consumption (Boğa et al., 2021; Budağ, 2009; Kamalak, 2007; Ünver et al., 2014). However, the tannin found in *Rheum ribes* L. was found to be high in all three maturation periods. Therefore, more care should be taken when using it in all three periods.

Table 1. Chemical compositions and condansed tannin content of *Rheum ribes* L. harvested at three stages.
Çizelge 1. Farklı hasat dönemlerindeki Rheum ribes L.'nin kimyasal bileşimi ve kondense tanen içeriği.

	Maturity stages				
Parameters	**Preflowering**	**Flowering**	**Seedling**	**SEM**	**Sig.**
DM	92.73^{c}	96.40^{b}	98.64^{a}	0.311	**
CA	6.81^{b}	14.15^{a}	6.11^{b}	0.305	**
CP	19.12^{a}	14.43^{b}	8.81^{c}	0.157	**
EE	3.04^{a}	1.94^{b}	2.86^{a}	0.251	**
ADF	24.88^{c}	30.54^{b}	37.63^{a}	1.315	**
NDF	36.99^{b}	52.07^{a}	53.98^{a}	0.671	**
CT	14.72^{a}	11.52^{b}	10.47^{c}	0.270	**

Means within the same row with differing superscripts (a–c) (P>0.05); ** P<0.05, S.E.M.: standard error mean, Sig: significance level.

As can be seen from Table 2, GP of *Rheum ribes* L. decreased with increased maturity. Gas and methane after 24 h incubation ranged between 29.73-40.60 ml, 2.63-5.50 ml respectively. It is thought that the reason for the decrease in gas production as the maturation period is due to the increase in ADF and NDF against digestible substances. It is well known that ADF and NDF contents are the parts of the plant that cannot be digested anymore. The gas released as a result of fermentation depends on the amount of digestible nutrients in the rumen, and it has been stated that the higher the amount of digestible nutrients, the more gas is produced (Blümmel and Orskov, 1993). The decrease in GP with increasing maturity was also a reflection of the decreased quality and was consistent with the findings of Kamalak et al. (2005a; 2005b) reported that a decrease in GP as the forage growing period extended.

Table 2. Gas production, ME and OMD of *Rheum ribes* L. harvested at three stages.
Çizelge 2. Farklı hasat dönemlerindeki Rheum ribes L.'nin gaz üretimi, ME ve OMSD.

	Maturity stages				
Parameters	**Preflowering**	**Flowering**	**Seedling**	**SEM**	**Sig.**
Total gas (ml)	40.60^{a}	37.28^{b}	29.73^{c}	1.068	**
CH_4 (%)	13.56^{a}	12.64^{b}	8.86^{c}	0.121	**
CH_4 (ml)	5.50^{a}	4.71^{b}	2.63^{c}	0.243	**
ME (Mjkg^{-1} DM)	9.87^{a}	8.69^{b}	6.97^{c}	0.131	**
OMD (%)	60.02^{a}	55.44^{b}	45.68^{c}	0.888	**

Means within the same row with differing superscripts (a–c) (P>0.05); ** P<0.05; S.E.M.: standard error mean, Sig.: significance level.

ME and OMD ranged from 6.97-9.87 Mj kg^{-1} KM, 45.68-60.02% respectively. The highest values of ME and OMD were recorded before flowering. OMD and ME of *Rheum ribes* L. also decreased with increasing maturity. As the amount of gas released as a result of fermentation decreased as the periods progressed, it decreased in ME and OMD. The decrease in CP concentration and gas production resulted in ME and OMD of *Rheum ribes* L. also decreased with increasing maturity. Such results support our present findings (Atalay ve Kamalak, 2019; Canbolat 2012; Giray, 2019; Kamalak ve ark., 2005a, 2005b; Kaplan ve ark., 2014; Kaplan ve ark., 2016; Kurt ve Kamalak, 2020). CH4% of total gas were significantly decreased with advancing maturity (P<0.05). Similarly, it has been reported in various studies that CH4% total gas was significantly

decreased with advancing maturity (Atalay ve Kamalak, 2019; Kaplan ve ark., 2016; Kurt ve Kamalak, 2020; Üke ve ark., 2017).

Gas production, ME and OMD were significant and negatively correlated with NDF ve ADF contents (Table 3). This result is consistent with the findings reported by (Aydın et al., 2007; Canbolat, 2012; Ceylan and Kamalak, 2019; Kamalak et al., 2011; Kamalak et al., 2005a, 2005b; Kamalak and Canbolat 2010; Kaplan et al., 2016). CP content was positively and significantly correlated with GP, which is in agreement with the earlier findings of Canbolat, (2013), Karabulut et al. (2007), Larbi et al. (1998).

According to the percentage of methane in the gas released as a result of fermentation, the antimethanogenic potential of the feeds is classified as low (>11% and ≤14%), medium (>6% and <11%), and high (>0% and <6%) (Lopez et al., 2010). CH4% total gas of *Rheum ribes* L. ranged from 8.86-13.56%. According to the classification the seedling maturity of *Rheum ribes* L. can be said to have anti-methanogenic properties, even if at moderate potential and pre-flowering and flowering maturity stages of *Rheum ribes* L. even if at low potential.

Table 3. Correlation coefficient (r) of the relationship of chemical composition with gas production, ME (MJ kg^{-1} DM) and OMD (%) of *Rheum ribes* L.
Çizelge 3. Rheum ribes L.'nin kimyasal bileşimi ile gaz üretimi, ME ve OMSD arasındaki korelasyonlar.

Parameters	DM	CA	CP	EE	NDF	ADF	CT
TG	-0.903**	0.270NS	0.0953**	-0.019NS	-0.795*	-0.979**	0.839**
CH_4 (%)	-0,910**	0.320NS	0.973**	-0.070NS	-0.779*	-0.957**	0.846**
CH_4 (ml)	-0.874**	0.406NS	0.954**	-0.153NS	-0.712*	-0.909**	0.799**
ME	-0.956**	0.178NS	0.989**	0.064NS	-0.863**	-0.985**	0.906**
OMD	-0.924**	0.266NS	0.974**	-0.017NS	-0.810**	-0.979**	0.861**

** P<0.05, NS: Non-significant (P>0.05).

CONCLUSION

This study provided useful information about the possible decrease in the nutritional value of *Rheum ribes* L. with increasing maturity. The chemical composition, in vitro total gas, ME, OMD of *Rheum ribes* L. were negatively affected by the maturity stage. It was concluded that *Rheum ribes* L. will provide more CP and ME energy for ruminants when harvested or grazed at the pre-flowering stage vegetative and flowering stages. *Rheum ribes* L. showed promising potential for ruminant animals. However, in this experiment the CT levels *Rheum ribes* L. at the three maturity stages were higher than those considered detrimental to ruminants. Therefore, care should be taken when using the animal feed.

CONFLICT OF INTEREST

The author must report under this title that there are no conflicts of interest.

DECLARATION OF AUTHOR CONTRIBUTION

Özer Kurt designed the study, participated in experiment, and drafted the manuscript.

REFERENCES

Andiç, S., Tunçtürk, Y., Ocak, E., & Köse, S. (2009). Some chemical characteristics of edible wild Rhubarb species (*Rheum ribes* L.). *Research Journal of Agriculture and Biological Sciences*, *5*, 973-977.

AOAC, (1990): *Official method of analysis.* Association of Official Analytical Chemists, 15th. Edition.

Atalay, A. İ., & Kamalak, A. (2019). Olgunlaşma dönemlerinin sirken (*Chenopodium album*) otunun kimyasal kompozisyonuna, besleme değerine ve metan üretimine etkisi. *Türk Tarım ve Doğa Bilimleri Dergisi*, *6*(3), 489-493. https://doi.org/10.30910/turkjans.595363

Aydın, R., Kamalak, A., & Canbolat, O. (2007). Effect of maturity on the potential nutritive value of burr medic (*Medicago polymorha*) hay. *Journal of Biological Science, 7*, 300-304. https://dx.doi.org/10.3923/jbs.2007.300.304

Baytop, T. (1984). Türkiye'de Bitkiler ile Tedavi. İstanbul Üniversitesi Yayınları.

Blummel, M., & Ørskov, E. R. (1993). Comparison of in vitro gas production and nylon bag degradability of roughages in predicting feed intake in cattle. *Animal feed science and technology, 40*(2-3), 109-119. https://doi.org/10.1016/0377-8401(93)90150-I

Boğa, M., Kocadayioğullari, F., & Can, M. E. (2021). Tanenlerin ruminant hayvan beslemede kullanımı. *Black Sea Journal of Engineering and Science*, 21-22. https://doi.org/10.34248/bsengineering.937301

Budağ, C. (2009). Baklagil tane yemleri ve ruminant beslenmede kullanımı. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 14*(2), 88-101. https://dergipark.org.tr/en/pub/yyufbed/issue/54365/738947.

Buxton, D. R. (1996). Quality related characteristics of forages as influenced by plant environment and agronomic factors. *Anim. Feed Sci. Technol*. *59*(1-3):37-49. https://doi.org/10.1016/0377-8401(95)00885-3

Çakılcıoğlu, U., & Türkoğlu, İ. (2007, April 30). Plants used for hemorrhoid treatment in Elaziğ central district [Paper presentation]. In I International Medicinal and Aromatic Plants Conference on Culinary Herbs, Antalya. https://doi.org/10.17660/ActaHortic.2009.826.11

Canbolat, O. (2012). Potential nutritive value of field binweed (*Convolvulus arvensis* L) hay harvested at three different maturity stages. *Kafkas Univ Vet Fak Derg, 18*(2), 331-335. https://doi.org/10.9775/kvfd.2011.5533

Canbolat, Ö. (2013). Farklı olgunlaşma dönemlerinin kolza otunun (*Brassica napus* L.) potansiyel besleme değeri üzerine etkisi. *Ankara Üniv. Vet. Fak. Derg*., *60*: 145-150. https://doi.org/10.1501/Vetfak_0000002568

Ceylan, E., & Kamalak, A. (2019). Farklı hasat zamanının pamuk dikeninin (O*nopordum acanthium*) kimyasal kompozisyonu, in vitro gaz ve metan üretimi üzerine etkisi. *Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi, 16(*1), 13-18. https://doi.org/10.25308/aduziraat.448250

Chang, S. J., Huang, S. H., Lin, Y. J., Tsou, Y. Y., & Lin, C. W. (2014). Antiviral activity of *Rheum palmatum* methanol extract and chrysophanol against Japanese encephalitis virus. *Archives of pharmacal research*, *37*(9), 1117-1123. https://doi.org/10.1007%2Fs12272-013-0325-x

Cullen, J. (1966). *Rheum* L. In: P.H. Davis (Ed), Flora of Turkey and the East Aegean Islands, Edinburg University Pres, Edinburg.

García-González, R., López, S., Fernández, M., Bodas, R., & González, J. S. (2008). Screening the activity of plants and spices for decreasing ruminal methane production in vitro. *Animal Feed Science and Technology*, *147*(1-3), 36-52. https://doi.org/10.1016/j.anifeedsci.2007.09.008

Giray, S., 2019. Hasat zamanının şevketibostan dikeninin (*Scolymus hispanucus*) kompozisyonuna, in vitro gaz üretimine ve metan üretimine etkisi. [Yüksek Lisans Tezi]. Kahramanmaraş Sütçü İmam Üniversitesi, Kahramanmaraş.

Goel, G., Makkar, H. P., & Becker, K. (2008). Effects of *Sesbania sesban* and *Carduus pycnocephalus* leaves and Fenugreek (*Trigonella foenum-graecum* L.) seeds and their extracts on partitioning of nutrients from roughage-and concentrate-based feeds to methane. *Animal Feed Science and Technology*, *147*(1-3), 72-89. https://doi.org/10.1016/j.anifeedsci.2007.09.010

Hu, B., Zhang, H., Meng, X., Wang, F., & Wang, P. (2014). Aloe-emodin from rhubarb (*Rheum rhabarbarum*) inhibits lipopolysaccharide-induced inflammatory responses in RAW264. 7 macrophages. *Journal of Ethnopharmacology*, *153*(3), 846-853. https://doi.org/10.1016/j.jep.2014.03.059

Kamalak, A. (2007). Kondense tanenin olumsuz etkilerini azaltmak için kullanılan katkı maddeleri ve yemlere uygulanan işlemler. *KSÜ Fen ve Mühendislik Dergisi*, *10*(2), 2007.

Kamalak, A., & Canbolat, O. (2010). Determination of nutritive value of wild narrow-leaved clover (*Trifolium angustifolium*) hay harvested at three maturity stages using chemical composition and in vitro gas production. *Tropical Grasslands*, *44*, 128-133.

Kamalak, A., Atalay, A. I., Ozkan, C. O., Kaya, E., & Tatliyer, A. (2011). Determination of potential nutritive value of Trigonella kotschi fenzl hay harvested at three different maturity stages. *Journal of Veterinary Faculty*, Kafkas University, *17*(4), 635-640. https://doi.org/10.9775/kvfd.2011.4553

Kamalak, A., Canbolat, O., Gurbuz, Y., Erol, A., & Ozay, O. (2005a) Effect of maturity stage on the chemical composition, in vitro and in situ degradation of tumbleweed hay (*Gundelia tuonefortii* L.). Small *Ruminant Research*, *58*, 149–156. https://doi.org/10.1016/j.smallrumres.2004.09.011

Kamalak, A., Canbolat, O., Gurbuz, Y., Ozkan, C. O., & Kizilsimsek, M. (2005b). Determination of nutritive value of wild mustard, Sinapsis arvensis harvested at different maturity stages using in situ and in vitro measurements. *Asian-Australasian Journal of Animal Sciences, 18*(9), 1249-1254. http://doi.org/10.5713/ajas.2005.1249

Kaplan, M., Kamalak, A., Özkan, Ç. Ö., & Atalay, A. İ. (2014). Vejetasyon döneminin yabani korunga otunun potansiyel besleme değerine, metan üretimine ve kondense tanen içeriğine etkisi. *Harran Üniversitesi Veteriner Fakültesi Dergisi, 3*(1), 1-5.

Kaplan, M., Üke, Ö., Kale, H., Yavuz, S., Kurt, Ö., & Atalay, A. İ. (2016). Olgunlaşma döneminin teff otunun potansiyel besleme değeri, gaz ve metan üretimine etkisi. *Iğdır Üniv Fen Bilimleri Enst Derg*, *6*(4), 181-186. https://doi.org/10.2159/jist.2016624170

Karabulut, A., Canbolat, O., Kalkan, H., Gurbuzol, F., Sucu, E., & Filya, I. (2007). Comparison of in vitro gas production, metabolizable energy, organic matter digestibility and microbial protein production of some legume hays. *Asian-Australasian Journal of Animal Sciences, 20*(4), 517-522. https://doi.org/10.5713/ajas.2007.517

Kaval, I., Behçet, L., & Cakilcioglu, U. (2014). Ethnobotanical study on medicinal plants in Geçitli and its surrounding (Hakkari-Turkey). *Journal of Ethnopharmacology*, *155*(1), 171-184. https://doi.org/10.1016/j.jep.2014.05.014

Kurt, A. A., & Kamalak, A. (2020). Hasat zamaninin meryemana dikeninin (*Silybum marianum*) kompozisyonuna, gaz üretimine, metan üretimine, sindirimine ve metabolik enerjisine etkisi. *Erciyes Üniversitesi Veteriner Fakültesi Dergisi*, *17*(2), 116-120. https://doi.org/10.32707/ercivet.760731

Larbi, A., Smith, J. W., Kurdi, I. O., Adekunle, I. O., Raji, A. M., & Ladipo, D. O. (1998). Chemical composition, rumen degradation, and gas production characteristics of some multipurpose fodder trees and shrubs during wet and dry seasons in the humid tropics. *Animal Feed Science and Technology*, *72*(1-2), 81-96. https://doi.org/10.1016/S0377-8401(97)00170-3

López, S., Makkar, H. P., & Soliva, C. R. (2010). Screening plants and plant products for methane inhibitors. In In vitro screening of plant resources for extra-nutritional attributes in ruminants: nuclear and related methodologies (pp. 191-231). Springer, Dordrecht. https://doi.org/10.1007/978-90-481-3297-3_10

Makkar, H. P. S., Blümmel, M., & Becker, K. (1995). Formation of complexes between polyvinyl pyrrolidones or polyethylene glycols and tannins, and their implication in gas production and true digestibility in in vitro techniques. *British Journal of Nutrition*, *73*(6), 897-913. https://doi.org/10.1079/BJN19950095

Menke, K. H. (1988). Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. *Animal research and development*, *28*, 7-5. https://cir.nii.ac.jp/crid/1573668925633603328#citations_container

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. https://doi.org/10.1017/S0021859600086305

Meral, R. (2017). Farklı sıcaklık derecelerinin uşkun bitkisinin antioksidan aktivitesi ve fenolik profili üzerine etkisi. *Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi*, *27*(1), 88-94. https://doi.org/10.29133/yyutbd.285999

Munzuroğlu, Ö., Karataş, F., & Gür, N. (2000). Işgın (*Rheum ribes* L.) bitkisindeki A, E ve C vitaminleri ile selenyum düzeylerinin araştırılması. *Turkish journal of biology*, *24*(3), 397-404. https://doi.org/10.3906/biy-9903-1

Özcan, M., Dursun, N., & Arslan, D. (2007). Some nutritional properties of *Prangos ferulacea* (L.) Lindl and *Rheum ribes* L. stems growing wild in Turkey. *International Journal of Food Sciences and Nutrition*, *58*(2), 162-167. https://doi.org/10.1080/09637480601154145

Soliva, C. R., Zeleke, A. B., Clement, C., Hess, H. D., Fievez, V., & Kreuzer, M. (2008). In vitro screening of various tropical foliages, seeds, fruits and medicinal plants for low methane and high ammonia generating potentials in the rumen. *Animal feed science and technology*, *147*(1-3), 53-71. https://doi.org/10.1016/j.anifeedsci.2007.09.009

Tuncturk, M., Celen, A. E., & Tuncturk, R. (2017). Nutrient content of three edible wild plants. From Polygonaceae Family. *Oxidation Communications*, *40*(1-II), 327-334.

Üke, Ö., Kale, H., Kaplan, M., & Kamalak, A. (2017). Olgunlaşma döneminin kinoa (*Chenopodium quinoa* Willd.)'da ot verimi ve kalitesi ile gaz ve metan üretimine etkisi. *Kahramanmaraş Sütçü İmam Üniversitesi Doğa Bilimleri Dergisi, 20*(1), 42-46. Doi: 10.18016/ksujns.51209

Ünver, E., Ağma Okur, A., Tahtabiçen, E., Kara, B., & Şamli, H. E. (2014). Tanenler ve hayvan besleme üzerine etkileri. *Türk Tarım-Gıda Bilim ve Teknoloji Dergisi*, *2*(6), 263-267. https://app.trdizin.gov.tr/publication/paper/detail/TVRnNE5EUXdNQT09.

Van Soest, P. J. (1994). Nutritional ecology of the ruminant Cornell University Press. https://doi.org/10.7591/9781501732355

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. https://doi.org/10.3168/jds.S0022-0302(91)78551-2