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ARAŞTIRMA MAKALESİ **RESEARCH PAPER**

Estimation of Chemical Composition, *In Vitro* Digestibility and Metabolic Energy of Peanut Straw and Waste of Peanut Oil Factory [*]

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Abstract: The objective of this study was to evaluate chemical composition, organic matter digestibility (OMD) and metabolic energy (ME) values of the most cultivated Osmaniye Virginia peanut variety straw, and peanut seed residue and peanut meal which are wastes of peanut oil factory in Osmaniye- Turkey for ruminant nutrition. The levels of OMD and ME of feed samples were determined by *in vitro* gas production method. The mean organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) levels of peanut straw, peanut seed residue and peanut meal were estimated as following 92.10, 89.22 and 93.70%; 10.22, 23.16 and 41.25%; 2.30, 8.21 and 6.45%; 51.14, 35.27 and 28.44%; 41.72, 18.83 and 13.20%; 8.77, 6.17 and 4.71% respectively. OMD%, ME_{OMD} and ME_{GP} MJ/kgDM values of peanut straw, peanut seed residue and peanut meal determined as 56.12, 61.38 and 71.80; 8.98, 9.82 and 11.49; 7.69, 7.03 and 8.10 respectively. The obtained results show that cultivated Osmaniye Virginia peanut variety straw, peanut seed residue and peanut meal are an excellent nutrients source to meet nutritional requirements of ruminant animals.

Keywords: *In vitro* digestibility, metabolic energy, nutrients, peanut straw, peanut meal, peanut seed residue.

Yerfıstığı Samanı ve Yerfıstığı Yağ Fabrikası Atıklarının Kimyasal Kompozisyonu, *İn Vitro* Sindirilebilirlik ve Metabolik Enerjisinin Belirlenmesi

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Öz: Bu çalışmanın amacı Osmaniye-Türkiye'de yetiştirilen en iyi kültürü yapılmış Osmaniye Virjinya yer fıstığı çeşidinin samanı ve yerfıstığı yağ fabrikası atıklarından elek altı tohum ve fıstık küspesinin kimyasal kompozisyonu, organik madde sindirilebilirliği (OMS) ve metabolik enerji (ME) değerlerinin ruminant besleme için belirlenmesidir. Yem örneklerinin OMS ve ME değerleri *in vitro* gaz üretim metodu ile belirlendi. Yerfıstığı samanı, elek altı ve fıstık küspesinin ortalama organik madde (OM), ham protein (HP), ham yağ (HY), nötral deterjan fiber (NDF), asit deterjan fiber (ADF) ve asit deterjan lignin (ADL) seviyeleri sırasıyla % 92.10, 89.22 ve 93.70; % 10.22, 23.16 ve 41.25; % 2.30, 8.21 ve 6.45; % 51.14, 35.27 ve % 28.44; % 41.72, 18.83 ve 13.20; % 8.77, 6.17 ve % 4.71 olarak hesaplandı. Yerfıstığı samanı, elek altı tohum ve küspenin % OMS, ME_{OMS} ve $ME_{GÜ}$ MJ/kgKM değerleri sırasıyla 56.12, 61.38 ve 71.80; 8,98, 9,82 ve 11,49; 7.69, 7.03 ve 8.10 olarak belirlendi. Bulunan sonuçlar, yetiştirilen Osmaniye Virginia fıstık çeşidinin samanı, elek altı tohumu ve küspesinin rminant hayvanların beslenme ihtiyaçlarını karşılamak için çok iyi bir besin maddeleri kaynağı olduğunu göstermektedir.

Anahtar kelimeler: Besin maddeleri, *İn vitro* sindirilebilirlik, metabolik enerji, yerfıstığı samanı, yerfıstığı küspesi, yerfıstığı elek altı tohum.

INTRODUCTION

Peanut is an essential crop in tropics and subtropical regions worldwide. The largest producers of peanuts are China, India, the USA, and certain African countries (Stalker & Wilson, 2015). Peanuts (*Arachis hypogaea*) are mostly produced in Adana and Osmaniye province of Turkey, and total peanut production was 424.000 tonnes in the year 2019 (TUIK, 2019). Consequently, the peanut straw production corresponded nearly 424.000 tonnes per year.

Peanuts (*Arachis hypogaea*) are an annual legume and mainly produced for human consumption due to its high protein and energy content; however, there are a considerable amount of peanut crop residue sources for livestock feeding left after harvesting the seeds (Hill, 2002; Pande et al., 2003). Since peanut forage contains a high level of protein, it been used as a ruminant feedstuff (Garduno-Lugo & Olvera-Novoa, 2008). Besides, Peanut meal is the product that remains after the extraction of oil from peanuts, and it been used as a protein-rich feed source for animal nutrition. Hence peanut straw, the residue of seeds and peanut meal are considered as by-products of peanut production (Feedipedia, 2017).

Peanut seeds contain a high amount of nutrients such as 50% fatty acids, 25% protein and 10% nitrogen-free extract. Average crude protein, nitrogen-free extract and mineral contents of peanut meal are 45, 24 and 5.5 % respectively (Arioglu, 2013). Perennial peanut forage is highly nutritious for beef and dairy cattle, and goats. It was reported in another study that the digestibility of peanut straw produced in Aydın, Turkey was higher in goats than sheep (Sevim, 2013). Khan et al. (2012) showed that peanut straw (*Arachis hypogaea L.*) might be an excellent alternative forage source for sheep nutrition. Blummel et al. (2005) reported that peanut straw is a -an excellent roughage source for sheep because of its higher organic matter digestibility and protein content. The nutritional quality of perennial peanut appears to be as good as alfalfa for ruminant animals (Hernández-Garay et al., 2004). Recently reported mean CP, EE, ash and the crude fiber content of peanut straw were 4.93%, 0.43%, 7.95% and 17.8%, respectively (Amuridin et al., 2019).

In vitro gas production technique has been widely used to determine organic matter digestibility and to estimate the metabolic energy (ME) of feedstuffs (Menke & Steingass,1988; Contreras-Govea et al., 2013).

The feeding values of peanut by-products have been affected by environmental factors such as genetic varieties, soil structure, and irrigation. At the time of harvesting large quantities of peanut straw and after oil extraction, peanut meal become available for feeding ruminants, Still, the nutritive values of peanut mostly Virginia variety produced in Osmaniye, Turkey were not well reported. The objective of this study was to evaluate the chemical composition, *in vitro* digestibility and ME values of the most cultivated variety peanut straw, peanut seed residue and peanut meal in Osmaniye province of Turkey.

MATERIAL AND METHOD

Animal material: The rumen fluid was collected from slaughtered cattle in Florya Meat Joint-Stock Company, Samsun, Turkey. Beef cattle were fed by grass hay (97 g CP/kgDM; 6 MJ ME/kg DM) ad libitum and 10 kg of a compound feed twice in a day in the morning and evening time. The compound feed contained 135 g CP, 11 MJ ME/ kg DM. Ruminal content was directly collected to anaerobically prepared with continuously CO_2 flushing into preheated thermos flask at 39 ºC. It was transported immediately from Florya slaughterhouse to the Ruminant Feed Evaluation Laboratory of OMU Faculty of Veterinary Medicine Department of Animal Nutrition and Nutritional Diseases. Collected ruminal content was strained through two or three layers of cheesecloth and kept at 39 ºC under a CO_2 atmosphere till using for *in vitro* gas production method.

Feed material: Peanut straw, seed residue and peanut meal samples were collected from Osmaniye province in Turkey. The quadruple samples from collected peanut straw, peanut seed residue and peanut meal were used for each analysis (n=20). Peanut straw, peanut seed residue and peanut meal samples were milled passing through a 1 mm sieve for chemical and mineral analysis and *in vitro* gas production method.

Chemical composition analysis: Chemical composition analysis was carried out in the Chemical Analysis Laboratory of OMU Faculty of Veterinary Medicine Department of Animal Nutrition and Nutritional Diseases. OM, CP, EE and ash contents of ground peanut by-product samples were determined according to AOAC methods (AOAC, 2006). CP was calculated as N x 6.25. NDF, ADF and ADL contents of peanut by-products were determined by using ANKOM 200 Fiber Analyzer (ANKOM Technology Corp. Fairport, NY, USA) using the method described by Van Soest et al., (1991). ME_{ADF} (MJ/kg DM) was estimated by the equation given below (Kirchgessner et al.,1977).

ME_{ADF}, MJ/kg KM=14.60-0.13x ADF

In vitro gas production method: *In vitro* gas production experiment was carried out in the Ruminant Feed Evaluation Laboratory of Department of Animal Nutrition and Nutritional Diseases, Faculty of Veterinary Medicine, Ondokuz Mayis University. The ANKOM RF gas production system (Ankom RF Gas Production

System, Ankom Technology, NY, USA) was used for measuring gas production. System parts are an incubator, 12 modules with 250 mL capacity, and recording computer. The produced gas pressure was recorded at 5 minutes intervals by using ANKOM RF gas production system program.

Approximately 1 g of ground samples were weighed and put into 12 modules. The prepared artificial salivia (Menke & Steingass,1988) was mixed with rumen fluid 4:1. A mixture of 100 mL of this solution was added to a preheated sample containing modules under anaerobic conditions by continuously flushing CO_2. Then modules transferred to the incubator at a temperature about 39 °C and pH about 6.5 to 6.8, and *in vitro* gas production system was started. The average cumulative pressure values were recorded at 0, 3, 6,12, 24, 48, 72 and 96 hours, and these values were converted to mL of gas at standard temperature and pressure.

OMD %, ME_{GP}, and ME_{OMD} (MJ/ kg DM) values of samples were estimated from gas measured by *in vitro* method at 24 h by using the below equations (Menke & Steingass, 1988).

$$ME_{GP}\,(MJ/kg\ DM) = 2.2 + 0.136\ GP + 0.057 CP + 0.0029\ EE \quad (1)$$

$$OMD\ (\%) = 57.2 + 0.365\ GP + 0.304\ CP - 1.98\ ADL \quad (2)$$

GP (mL/200 mg DM)

$$ME_{OMD}\,(MJ/kg\ DM) = 0.16\ OMD \quad (3)$$

OMD: Organic matter digestibility

ME_{GP}: Metabolisable energy calculated from gas production

ME_{OMD}: Metabolisable energy calculated from organic matter digestibility.

Statistical analysis: One-Way analysis of variance and multiple comparisons among DM, Ash, OM, CP, EE, NDF, ADF, ADL, GP, OMD and ME values of peanut straw, peanut seed residue and peanut meal means were performed by Duncan's new multiple ranges (SAS, 2007). Means differences were considered significant at $P<0.01$.

RESULTS AND DISCUSSION

Chemical composition of peanut straw, peanut seed residue and peanut meal is shown in Table 1. The CP content was found to be 10.22, 23.16 and 41.25 % of peanut straw, peanut seed residue and peanut meal, respectively. Statistically significant differences were found between the CP mean values of peanut straw, peanut seed residue and peanut meal ($P<0.01$). The mean CP level of peanut straw (%) was quite higher then previously reported mean CP (4.93%), however. ash contents were similar to each other (Amuridin et al., 2019). As the protein value of the feedstuff increases, the value of the feedstuff is considered as high-quality feed. However, bacteria in the rumen have been reported to need at least 10 % protein - to perform microbial activities (Norton, 2016). In the present study, any of the peanut by-products investigated contains more than 10 % CP. The obtained mean CP levels of peanut straw were similar to previously reported values for peanut NC-7 variety straw (Ozyigit & Bilgen, 2013). The mean CP levels of peanut meals collected from 17 different peanut oil extracting factories were given as 45.6 ± 2.8 % in the range of 40.1% - 50.9% (Batal et al., 2005). Since peanut seed residues contain high CP, it may be used as a good source for animal nutrition.

Table 1. Chemical composition of peanut straw, peanut seed residue and peanut meal (mean ± SE, n=20.

Crude nutritive values (%)	Peanut straw	Peanut seed residue	Peanut meal
DM	93.01±0.15	91.8±0.23	92.28±0.21
Ash	7.90^{b}±0.09	10.78^{a}±0.11	6.3^{c}±0.05
OM	92.1^{b}±0.08	89.22^{c}±0.15	93.70^{a}±0.10
CP	10.22^{c}±0.14	23.16^{b}±0.12	41.15^{a}±0.13
EE	2.30^{c}±0.08	8.21^{a}±0.04	6.45^{b}±0.09
NDF	51.14^{a}±0.10	35.27^{b}±0.08	28.44^{c}±0.10
ADF	41.72^{a}±0.08	18.83^{b}±0.09	13.20^{c}±0.12
ADL	8.77^{a}±0.11	6.17^{b}±0.13	4.71^{c}±0.14
ME, MJ/kg DM	9.18^{b} ±0.04	9.38^{b} ±0.03	12.88^{a} ± 0.05

$^{a,b,c.}$ Row means with different superscripts differ significantly at P< 0.01DM: Dry Matter, OM: Organic Matter, CP: Crude Protein, EE: Ether Extract, NDF: Neutral Detergent Fiber, ADF: Acid Detergent Fiber, ADL: Acid Detergent Lignin, ME: Metabolic Energy, n: Number of samples.

The determining crude oil or EE values of peanut straw, peanut seed residue and peanut meal were 2.30, 8.21 and 6.45%, respectively. The differences between the mean values of peanut by-products were significantly different ($P<0.01$). The estimated mean EE value of peanut meal was higher than the values reported by Heuze et al., (2016). This situation may be due to the different techniques used for seed processing in oil production factories. Necessary attention has to be paid when the high fat containing feedstuffs like peanut seed residue was used in ruminant animals diet because they may suppress rumen cellulolytic bacteria and cause impairment on digestibility of plant cell wall components (Van Soest, 1994). Fieroni et al. (2015) showed that palm oil diet impaired ruminal function parameters without contributing effectively in providing unsaturated fatty acid into the duodenum of beef cattle.

The obtained mean ash levels of peanut straw, peanut seed residue and peanut meal were 7.90, 10.78 and 6.30% consecutively. Differences between mean values of peanut by-products were significant($P<0.01$). Ash% values of peanut production by products are consistent with the values reported by Etela et al., (2011). It has been shown that the by-products of peanut Osmaniye Virginia variety production can be used as animal feedstuffs in terms of ash content of straw, peanut seed residue and peanut meal.

In our study, the obtained mean NDF, ADF and ADL levels of peanut straw, peanut seed residue and peanut meal were 51.14, 35.27 and 28.44%; 41.72, 18.83 and 13.20%; 8.77, 6.17 and 4.71%, respectively. Differences between NDF, ADF and ADL mean values of peanut by-products were significant($P<0.01$). The

components of the cell wall found in the structures of plant originated feed especially lignin, determine the digestibility of feedstuffs (Van Soest, 1994). Feed intake is directly related toits NDF content. However, ADF content of feeds determines their digestibilities. The estimated NDF, ADF and ADL mean values of peanut by-products were found similar to values previously reported and summarized in Feedipedia (2017). ME_{ADF} contents of peanut by-products were 9.18, 9.38 and 12.88 MJ/kg DM, consecutively. The highest ME_{ADF} value was determined for peanut meal. Differences in mean values were significantly important for peanut by-products (P<0.01).

The cumulative Ppsi, cumulative GP mL, OMD %, MEOMD (MJ/kg DM) and MEGP (MJ/kgDM values of peanut straw, peanut seed residue and peanut meal estimated by using of *in vitro* gas production method is presented in Table 2. Mean Ppsi, cumulative GP ml/200 mg DM, OMD %, ME_{OMD} (MJ/kg DM) and ME_{GP} (MJ/kg DM) were 14.58, 10.36 and 12.63 Psi; 36.12, 25.66 and 31.29 mL; 56.12, 61.38 and 71.80%; 8.98, 9.82 and 11.49 MJ/kg DM; 7.69, 7.03 and 8.81 MJ/kg DM, respectively. There were statistically significant differences between of peanut by-products *in vitro* gas production parameters (P<0.01). The major causes of the differences in gas production, OMD and ME values of peanut by-products because of the substantial differences in the estimated amount of CP, EE, NDF, ADF and ADL levels of peanut by-products. The estimated mean OMD and ME values of peanut Osmaniye Virginia straw, seed residue and meal were in the range of previously reported levels (Batal et al., 2005; Feedipedia, 2017).

Table 2. Cumulative gas production volume at 24 h (P_{psi} and GP_{mL}), organic matter digestibility (OMD) and metabolic energy (ME_{OMD} and ME_{GP}) values of peanut straw, peanut seed residue and peanut meal (mean ± SE, n=20).

Gas production parameters	Peanut straw	Peanut seed residue	Peanut meal
P_{psi}	14.58^{a}±0.15	10.36^{c}±0.17	12.63^{b}±0.13
GP_{mL}	36.12^{a}±0.21	25.66^{c}±0.22	31.29^{b}±0.29
OMD%	56.12^{c}±0.09	61.38^{b}±0.13	71.80^{a}±0.16
ME_{OMD} (MJ/kgDM)	8.98^{c}±0.05	9.82^{b}±0.04	11.49^{a}±0.06
ME_{GP}(MJ/kgDM)	7.69^{b}±0.10	7.03^{c}±0.09	8.81^{a}±0.14

[a,b,c.] Row means with different superscripts differ significantly at P< 0.01. n:Number of samples.

CONCLUSION

In conclusion, the estimated nutrients, organic matter digestibility and metabolic energy of peanut Osmaniye Virginia variety straw, seed residue and meal show that these by-products may be used as a nutrient-rich feedstuff for ruminant animal nutrition.

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