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Estimation of chemical composition, in vitro gas production, metabolizable energy, net energy lactation values of different peanut varieties and line by Hohenheim in vitro gas production technique

Estimativa da composição química, produção de gás in vitro, energia metabolizável, energia líquida dos valores de lactação de diferentes variedades de amendoim e linha pela técnica de produção de gás in vitro Hohenheim

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Highlights

Peanut is rich in amino acids, minerals, and vitamins and crude protein.
Waste from agricultural processing factories is one of the sources of environmental pollution.
The use of new feed sources as animal feedstuff is necessary.

Abstract

This study was carried out to determine the nutritional value of some selected peanut varieties and line in the Eastern Mediterranean Agricultural Research Institute of Adana, Turkey. The peanut varieties used were Gazipasa, Sultan, NC7, Cihangir, and Halisbey; while the peanut line was DA335/2011. The chemical composition, metabolizable energy (ME), net energy lactation (NEL) and organic matter digestibility (OMD) of the selected peanut varieties and line were determined through Hohenheim in vitro gas production technique. Incubation times for Hohenheim gas production technique were 3, 6, 9, 12, 24, 48, 72 and 96 hours. The analysis of variance (General Linear Model) was carried out using the SPSS package program.

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The differences among groups in terms of nutrient contents were found to be significant (P ≤ 0.05), except for dry matter (DM) and hemicellulose (HC). The highest crude protein (CP) (40.13%) was found in Sultan variety, while the crude oil (CO) content was found to be between 21.32 and 31.01%. The ADF, NDF, and ADL content of the peanut varieties and line were within the ranges of 2.32-7.91%, 4.85-9.88%, and 0.43-2.62%, respectively. Conversely, the Sultan variety had the highest crude cellulose (CC) value, Cihangir variety was determined to contain the highest hemicellulose (HC) value. The differences in 24 hour gas and methane production among different peanut varieties and line were found to be not-significant. (P > 0.05).
Key words: Peanut. Nutrient composition. *In vitro* gas production. Metabolizable energy.

Resumo

Este estudo foi realizado para determinar o valor nutricional de algumas variedades e linhagens de amendoim selecionadas no Eastern Mediterranean Agricultural Research Institute de Adana, Turquia. As variedades de amendoim utilizadas foram Gazipasa, Sultan, NC7, Cihangir e Halisbey; enquanto a linha de amendoim foi DA335 / 2011. A composição química, energia metabolizável (ME), energia líquida de lactação (NEL) e digestibilidade da matéria orgânica (OMD) das variedades e linhagens de amendoim selecionadas foram determinadas através da técnica de produção de gás in vitro de Hohenheim. Os tempos de incubação para a técnica de produção de gás Hohenheim foram 3, 6, 9, 12, 24, 48, 72 e 96 horas. A análise de variância (General Linear Model) foi realizada com o programa SPSS Package. As diferenças entre os grupos quanto aos teores de nutrientes foram significativas (P ≤ 0,05), exceto para matéria seca (MS) e hemicelulose (HC). A maior proteína bruta (PB) (40,13%) foi encontrada na variedade Sultan, enquanto o teor de óleo bruto (CO) ficou entre 21,32 e 31,01%. O conteúdo de ADF, NDF e ADL das variedades e linha de amendoim estava dentro dos intervalos de 2,32-7,91%, 4,85-9,88% e 0,43-2,62%, respectivamente. Por outro lado, a variedade Sultan teve o maior valor de celulose bruta (CC), e a variedade Cihangir foi conteve o maior valor de hemicelulose (HC). As diferenças na produção 24 horas de gás e metano entre as diferentes variedades de amendoim e linha foram consideradas não significativas. (P > 0,05).
Palavras-chave: Amendoim. Composição de nutrientes. Produção de gases *in vitro.* Energia metabolizável.

Introduction

Peanut (*Arachis hypogaea* L.), an oil seed plant from the legume (Faboceae) family, is rich in amino acids, minerals, and vitamins and contains 40-60% fat and 25% crude protein (CP) (Sahin, 2014). Hepsag (2018) stated that peanut seeds contain 45-55% fat, 20-25% protein, 16-18% carbohydrate, and 5% mineral substances such as K, Ca, Mg, P, and S, as well as the vitamins A, B, and E.

Recently, the agricultural wastes have been started to be used successfully in animal and poultry feeding (Arıoglu, 2014; Azizi, Seidavi, Ragni, Laudadio, & Tufarelli, 2018; Seidavi, Azizi, Ragni, Laudadio, & Tufarelli, 2018). There are many advantages of using food by-products such as peanut, and these advantages include the suitability for crop rotation, making good use of the nutrients in the cropland, and leaving a clean, semi-treated, and nitrogen-rich soil to the next plant. In addition, its importance increases even more thanks to fact that the peanut pulp and its green parts can be successfully used as forage and its shell in food or feed industry (Kokten, Kaplan, Seydesoglu, Ozdemir, & Boydak, 2014). Moreover, using agroindustrial by-products in animal nutrition has been successfully adopted as a strategy to reduce feeding costs and to cope with the need to recycle waste material, which is costly to dispose of (Tufarelli, Introna, Cazzato, Mazzei, & Laudadio, 2013). Thus, also peanut by-product could be a valuable alternative ingredient because of its low price compared with conventional raw material, where the peanut oil industries play an important economic role. Moreover, an opportunity to capture a share of the by-product feed market may exist for peanut oil processors currently disposing of their peanut waste.

In a previous study, the animal nutritional values of hays from different peanut (*Arachis hypogaea*) varieties were examined, and it was assessed that Florispan and Arıoğlu-2003 varieties, which were among the 10 varieties used, differed with their higher CP and DM consumptions compared to other varieties (Kokten, Kaplan, Seydesoglu, Ozdemir, & Boydak, 2014).

Arıoglu, Bakal, Gulluoglu, Kurt and Onat (2016) found that the CO contents of different peanut seed varieties [Halisbey, Sultan, NC-7, Osmaniye 2005, Batem 5025, Florispan, Brantley, Wilson, Georgia Green, Ha-runner, Flower 22 (V-1), Flower 32 (V-2), and Flower 36 (V-3)] were within the range of 47-51% and their CP contents were within the range of 24-28%. In their study determining the CP contents of Gazipasa, Sultan, DA35/2011, and NC-7; Macar, Macar, Cil, Oluk and Cil (2018) reported that Cihangir and Halisbey varieties and line, NC-7 variety had the highest CP content (30.6%), followed by the DA35/2011 line with 29.6%. There was no statistically significant difference between the CP levels of Sultan (26.9%) and Cihangir (27.2%) varieties, and the same occurred for Gazipaşa (27.7%) and Halisbey (27.8%) varieties. In another study, the CP contents of peanut varieties, as potential animal feed, were found to be between 24.80 and 29.60%, and the average CP content was 26.84% (Kılınccerker & Arıoglu, 2019).

Therefore, based on previous trials, the purpose of this study was to determine the nutritional value of different peanut seed varieties (Gazipasa, Sultan, NC7, Cihangir, and Halisbey) and line (DA335/2011) in the Eastern Mediterranean Agricultural Research Institute under the conditions of Adana in Turkey.

Materials and Methods

This study was carried out with peanut that was grown on the fields of Eastern Mediterranean Agricultural Research Institute located in Doğankent in Adana under conditions typical of peanut production in Turkey.

Feed material

The feed material of the study consisted of different peanut varieties (Gazipasa, Sultan, NC7, Cihangir, and Halisbey) and line (DA335/2011) grown in the Eastern Mediterranean Agricultural Research Institute, Adana, Turkey. Each variety was planted in 5 parcels and a sample of 1 kg was taken from each parcel for each variety. 5 repetitions were taken from each feed.

Soil material

Soil samples were taken before sowing and the necessary analyzes were conducted to determine needs for fertilizer. A standard application of 8-10 kg P_2O_5/dekare and 5-6 kg N/dekare was applied to the entire peanut production area into the bottom. 15 kg of urea was added to the top. The peanut planter was adjusted to ensure a planting depth of 6 cm and seeds were spaced 15 cm apart on the ridges. The rows are arranged to be 70 cm. Chemical analysis results of soil samples are shown in Table 1.

Table 1
Chemical analysis of soil samples

Organic matter	P_2O_5 %	K_2O	pH	EC (dSm^{-1})	Lime, %	Saturation, %
1.04	3.16	63.06	7.82	0.437	16.36	53.25

P_2O_5: Phosphorus pentoxide, K_2O: Potassium oxide, EC (dSm^{-1}): Electrical conductivity,

The soil structure of the peanut production areas was light-alkaline, salt-free and clayey-loamy. Its content was high in lime, low in organic matter (OM). Saturation is 53.25%. Available K_2O is good; available P2O5 is low.

During the peanut growing season, 213.3 mm of precipitation was received. The highest average value for rainfall as mm was observed in March at 115.8 mm. Table 2 shows the temperature, humidity and precipitation amounts of peanuts. The highest average value for air temperature was observed in August at 29.6°C. According to the long-term average, the average temperature of the peanut growing period in Adana location is 22.4ºC. The highest average value for relative humidity was observed in July at 69.3%. According to the long-term average, the relative humidity of the peanut growing period in Adana location is 66.3%.

Chemical analyses

The samples of five different peanut species and lines as seed were sent to the feed laboratory in the Department of Zootechnics, Faculty of Agriculture, Erciyes University, where the nutrient analyses were carried out.

Table 2
Weather during the growing season for peanut

Months	Air Temperature, °C		Relative Humidity, %		Rainfall, mm	
	Long years average	Mean	Long years average	Mean	Long years average	Mean
March	13.3	13.9	65.1	64.6	65.4	115.8
April	17.3	15.8	66.8	62.5	51.2	7.9
May	21.6	21.7	66.0	64.3	47.3	81.0
June	25.5	24.2	66.7	69.1	20.5	0.0
July	28.0	28.0	66.6	69.3	6.3	0.0
August	28.4	29.6	66.7	62.1	5.6	8.6
Total	22.4	22.2	66.3	65.3	196.3	213.3

The dry feed samples were first ground in a mill having a sieve diameter of 1 mm and then used for the analyses. In order to determine the DM content, the ground samples were kept in an oven at 70°C for 24 hours and the differences between the weights before and after baking were computed and expressed in DM %. In order to determine the CA content, the samples were burned in a muffle furnace at 550 °C for 4 hours. Kjeldahl method was used to determine the nitrogen (N) content. The crude protein (CP) content was computed using the following formula: CP % = N×6.25 (Association of official Analytical Chemists [AOAC], 1990). The crude oil (CO) analysis was carried out as per the method reported by AOAC (1990) using SER148 Soxhlet (Velp Scientifica, Milan, Italy). The NDF and ADF contents constituting the cell wall components of the feeds were determined as per the methods reported by Van Soest, Robertson and Lewis (1991) using ANKOM 200 fiber analyzer (ANKOM Technology, NY, USA). In computing the CC values, the following equation, reported by Pinkerton (2005), was used: CC % = 0.80 x ADF%. The HC contents were computed by subtracting the ADF values from the NDF values. In computing the NFC values, the following equation by Weiss, Conrad and St Pierre (1992) was used: NFC % = 100- (NDF % + CP % + CO % + CA %).

In vitro gas production

For the in vitro gas production (GP), the feeds were in vitro incubated with rumen fluid supplied from the fistulated sheep in glass syringes in accordance with the principles specified by Menke & Steingass (1988). Then, 100 ml syringes were supplemented with 0.200 g of dry samples. The syringes with only the rumen fluid were incubated and used as blank. The incubations were carried out in three replicates. The pre-warmed syringes (39°C) were filled with 30 ml of rumen fluid - buffer mixture and incubated in a water bath at 39°C. Gas production readings were taken before (0) and 24 hours after the incubation. The resultant GP values were corrected for blank and hay standards.

The following equations by Menke, Raab, Salewski, Steingass and Fritz (1979) were used to calculate metabolizable energy (ME), net energy lactation (NEL), and organic matter digestibility (OMD) of the silage samples:

$$ME\ (Mcal/kg\ DM) = (2.20 + 0.1136 \times GP + 0.0057 \times CP + 0.00029 \times CO^2) / 4.184$$

$$NEL\ (Mcal/kg\ DM) = (1.64 + 0.269 \times GP + 0.00078 \times GP^2 + 0.0051 \times CP + 0.01325 \times CO) / 4.186$$

$$OMD\ (\%) = 14.88 + 0.889 \times GP + 0.45 \times CP + 0.0651 \times CA$$

Statistical analyses

The analysis of variance (General Linear Model procedure) was carried out using the Statistical Package for the Social Sciences [SPSS] (1999) package program to determine the differences among the means. The Duncan's multiple comparison test was also used to determine the significance levels of the differences.

Results and Discussion

The dry matter (DM), CA, CP, and CO; the ADF, NDF, and ADL; and the crude cellulose (CC), hemi cellulose (HC), and NFC contents of the peanut varieties and line were shown in the Tables 3, 4, and 5, respectively. The 24 h in vitro gas and methane production, metabolizable energy (ME), net energy lactation (NEL) ingredients of the peanut varieties and line when incubated with rumen buffered liquid in vitro were shown in the Table 6.

As can be seen from the Tables 3, 4, and 5; the differences between the varieties and line in terms of CA, CP, and CO contents (P <0.05); the ADF, NDF, and ADL contents (P <0.05); and the CC and NFC contents (P <0.05) were found to be statistically significant.

Table 3
Dry matter (DM), CA, CP, and CO contents of the peanut varieties and line

Variety and line	DM, %	CA, % DM	CP, % DM	CO, % DM
Gazipasa	96.39	2.60[c]	34.76[c]	21.99[c]
NC-7	96.83	2.45[d]	38.42[b]	25.38[bc]
Cihangir	96.81	2.75[ab]	38.59[b]	28.99[ab]
Sultan	96.53	2.72[b]	40.13[a]	31.01[a]
DA 2011-335	96.33	2.51[d]	39.37[ab]	21.32[c]
Halisbey	96.29	2.80[a]	39.18[ab]	24.97[bc]
SEM	0.082	0.039	0.529	1.127
P	0.180	<0.001	<0.001	0.014

DM: Dry matter; CA: Crude ash; CP: Crude protein; CO: Crude oil; SEM: Standard error of means; [a,d]: The values in a column with different superscripts differ significantly at P < 0.05.

Table 4
ADF, NDF and ADL contents of the peanut varieties and line

Variety and line	ADF, % DM	NDF, % DM	ADL, % DM
Gazipasa	3.38[cd]	5.79[c]	1.69[b]
NC-7	3.56[c]	5.66[c]	0.68[d]
Cihangir	5.21[b]	7.90[b]	1.92[b]
Sultan	7.91[a]	9.88[a]	2.62[a]
DA 2011-335	5.18[b]	7.85[b]	1.07[c]
Halisbey	2.32[d]	4.85[c]	0.43[d]
SEM	0.552	0.532	0.229
P	<0.001	0.001	<0.001

ADF: Acid detergent fiber; NDF: Neutral detergent fiber; ADL: Acid detergent lignin; SEM: Standard error of means; [a,d]: The values in a column with different superscripts differ significantly at P < 0.05.

Table 5
Crude cellulose (CC), hemi cellulose (HC), and NFC contents of the peanut varieties and line

Variety and line	CC, % DM	HC, % DM	NFC, % DM
Gazipasa	1.69[e]	2.41	34.86[a]
NC-7	2.88[cd]	2.10	28.09[b]
Cihangir	3.29[bc]	2.69	21.77[c]
Sultan	5.29[a]	1.97	16.26[c]
DA 2011-335	4.11[b]	2.67	28.94[b]
Halisbey	1.90[de]	2.53	28.20[b]
SEM	0.387	0.184	1.847
P	0.001	0.895	0.003

CC: Crude cellulose; HC: Hemi cellulose; NFC: Nonstructural carbohydrate; SEM: Standard error of means; [a,e]: The values in a column with different superscripts differ significantly at $P < 0.05$.

As can be seen from the Table 6, the differences between the varieties and line in terms of GP, CH4, and OMD were not statistically significant ($P > 0.05$). The ME and NEL values were statistically significant in varieties and line ($P < 0.05$).

Table 6
The 24 h in vitro gas and methane production, metabolizable energy (ME), and net energy lactation (NEL) ingredients of the peanut genotypes when incubated with rumen buffered liquid

Varieties and line	24 h GP, ml	24 h CH4, ml	ME, MJ/kg DM	NEL, MJ/kg DM	OMD, %
Gazipasa	17	2.81	10.43[c]	3.76[b]	45.80
NC-7	17.5	2.96	11.37[b]	4.03[a]	47.89
Cihangir	18	2.85	12.1[ab]	4.13[a]	48.43
Sultan	16	2.73	12.30[a]	4.04[a]	47.34
DA 2011-335	14.5	2.47	10.30[c]	3.73[b]	45.65
Halisbey	17	2.58	11.29[b]	4.02[a]	47.81
SEM	0.395	0.065	0.238	0.050	0.372
P	0.069	0.279	0.005	0.028	0.089

SEM: Standard error of mean; P: Probability value; [a, b, c, d]: The means in the same column with different superscripts are significantly different; 24 h GP: 24 h *in vitro* gas production (ml/200 mg DM); 24 h CH4: *in vitro* methane production in total gas for a 24-hour-incubation (ml/200 mg DM); ME: metabolizable energy (MJ/kg DM); NEL: net energy lactation (MJ/kg DM).

The DM values ranged between 96.29% and 96.83%. The variation observed among the treatment groups in terms of DM content was found to be statistically insignificant ($P > 0.05$). Latif, Pfannstiel, Makkar and Becker (2013) asserted that the peanut seed contained 94.1% DM, 51.8% CO, 26.0% CP, and 2.1% CA; while in another study, the moisture content of peanut varieties was found to be 5.63% (Akkaya et al., 2017). The moisture contents of peanut varieties were determined to range between 4.12 and 4.75% by Mora-Escobedo, Hernández-Luna, Joaquín-Torres, Ortiz-Moreno and Robles-Ramírez (2015), between 6.22% and 6.62% by Ginting, Rahmianna and Yusnawan (2018), as 5.25% by Yadav, Edukondalu, Patel and Rao (2018), between 5.53 and 5.93% by Shibli, Siddique, Raza, Ahsan and Raza (2019), and between 3.93 and 4.85% by Zahran and Tawfeuk (2019). The recommended moisture content for peanuts is 6% (Barbara et al., 2012).

In our study, the CP contents of different peanut varieties and line ranged between 34.76% (Gazipasa) and 40.13% (Sultan). The average CP content was calculated to be 38.41% for the peanut varieties and line. The average CP content obtained as a result of our study (38.41%) was higher than the values found by Asibuo, Akromah, Adu-Dapaah and Kantanka (2008) (18.92-30.53%), Zhang, Wang, Tang and Wang (2009) (26.1-28.6%), Canavar (2011) (23.66%), Kadiroglu (2012) (26.26-32.38%), Asık, Yıldız and Arıoglu (2018) (20.32-32.38%), Yadav, Edukondalu, Patel and Rao (2018) (25.48%), and Zahran and Tawfeuk (2019) (25.07-28.20%).

Akkaya et al. (2017) reported that the average CP content of peanut varieties was 24.94%. Asık, Yıldız and Arıoglu (2018) determined the CP values of the Sultan, NC7, Cihangir, and Halisbey varieties, which were also used in our current study, as 24.72, 25.40, 25.27, and 24.54%, respectively; while Kadiroglu (2012) found the CP contents of peanut varieties NC-7 and Halisbey as 32.38 and 29.94%, respectively. The differences between the CP values found in the literature and in our study may have resulted from the different environmental conditions of the site where the study was carried out, the delay of the harvest time, the difference in total precipitation received and temperature during the vegetation, and the difference of varieties and lines.

In our study, the crude oil (CO) contents of peanut varieties and line were found to be within the range of 21.32-31.01%, and the average CO ratio was found as 25.61% ($P<0.05$). The highest CO content was found in Sultan variety with 31.01%. Examining the effect of harvest time on CO in peanut, Canavar (2011) asserted that the CO contents at each harvest time took different values, and that there was an increase in the CF contents as the harvest time was delayed. The researcher found the average CO content as 37.64%. Caliskan, Caliskan, Arslan and Arıoglu (2008) found the CO content of peanuts as 49.5-52.6%; while Kadiroglu (2012) as 48.58-51.07%; Mora-Escobedo, Hernández-Luna, Joaquín-Torres, Ortiz-Moreno and Robles-Ramírez (2015) as 37.90-56.31%, Akkaya et al. (2017) as 49.07%, Asık, Yıldız and Arıoglu (2018) as 51.42%, Yolbas (2018) as 48.90%, Shibli, Siddique, Raza, Ahsan and Raza (2019) as 49.80-50.90%; and Zahran and Tawfeuk (2019) found that the fat contents in 5 different peanut varieties were within the range of 50.45-52.12%.

Kadiroglu (2012) found that the CO content of NC-7 and Halisbey peanut varieties were within the range of 47.94-50.36% and 46.72-50.24%, respectively. Kurt, Bakal, Gulluoglu, Onat and Arıoglu (2016) found the CO content of Halisbey, Sultan, and NC-7 varieties as 46.22, 46.33, and 43.71%, respectively. Asık, Yıldız and Arıoglu (2018) found the CO contents of Sultan, NC7, Cihangir, Halisbey varieties, which were also used in our current study, as 50.40, 52.64, 49.95 and 50.77%, respectively; while Macar, Macar, Cil, Oluk and Cil (2018) stated that the CO content of different peanut varieties (Gazipasa, Sultan, NC7, Cihangir, and Halisbey) and line (DA335/2011) used in our study ranged between 43.9% and 45.9%; the difference in CO contents of the varieties were statistically insignificant; the CO contents of Gazipasa, Sultan, DA35/2011, NC-7, Cihangir, and Halisbey varieties and line were 45.0, 43.9, 44.7, 46.4, 45.5 and 45.9%, respectively; and that NC-7 variety had the highest CO content. Karabulut and Tuncturk (2019) found that the CO content of NC-7, Gazipasa, Halisbey, Sultan, and Cihangir varieties were 33.6, 35.7, 36.1, 37.4 and 36.4%, respectively.

The difference in the crude oil (CO) values in different studies may have resulted from the differences in the times when the trials were carried out, varieties or lines, environmental conditions, and harvest times. Cil, Cil, Akkaya and Sahin (2016) stated that the high rate of fat in peanuts was mostly caused by the genotype, and the cultivation technique and ecological factors also had an effect. Zaki, Amal, Ahmed, Hassanein and Mohamed (2018) found that the CO content was affected by variety, year, and fertilization, and the CO content of peanut varieties ranged between 47.78 and 48.01%. In another study, it was found that the CO content of peanut varieties ranged between 43.54 and 47.68% (Kılınccerker & Arıoglu, 2019). The recommended CO content for peanuts is 45.90% (Barbara et al., 2012).

While the crude ash (CA) content of the peanut varieties and line had the lowest value in NC-7 variety with 2.45%, Halisbey variety had the highest CA with 2.80% ($P < 0.05$). In a study, it was stated that the CA content of the peanut was within the range of 2.30-2.67% (Canavar, 2011). Harvest time is one of the factors affecting CA; and as the harvest is delayed, the CA content increases. Campos-Mondragón et al. (2009) reported that the CA values of 6 different peanut varieties ranged between 2.0 and 2.5%; while Ibraheem, Kabeir, Mohammed and Bhagiel (2015) found it as 1.13%. Mora-Escobedo, Hernández-Luna, Joaquín-Torres, Ortiz-Moreno and Robles-Ramírez (2015) found the ash content of peanut varieties between 2.22 and 2.50%, while Yadav, Edukondalu, Patel and Rao (2018) found it to be 1.84%. Shibli, Siddique, Raza, Ahsan and Raza (2019) found the CA content in 3 different peanut varieties to range between 2.00 and 2.17%. Zahran and Tawfeuk (2019) found the ash content in 5 different peanut varieties to range between 1.75 and 2.80%. The recommended ash content for peanuts is 2.30% (Barbara et al., 2012).

Containing cellulose, lignin, and hemicellulose in its structure, NDF is difficult to digest for the ruminant animals. NDF is consisted of hemicellulose, cellulose, and lignin (Sezmis & Gursoy, 2020). Low NDF values in feed are a desirable feature for animals and associated with the increased animal feed consumption. The average NDF value was found as 6.98% in our study. The differences observed in terms of NDF in the literature stem from the ecological conditions, variety differences, and cultural applications. In a previous study, it was determined that the NDF contents of hays from different peanut varieties ranged between 34.81 and 45.66% and there was a statistically significant difference between the varieties (Kokten, Kaplan, Seydesoglu, Ozdemir, & Boydak, 2014). In a study on this subject, it was found that the NDF values of processed peanut stalks did not differ significantly between the varieties and ranged between 53.1 and 60.7% (Oteng-Frimpong, Konlan, & Denwar, 2017).

The ADF value, an indicator of digestibility of roughages according to Van Soest (1967), was found to be 4.59% in our study on the basis of variety and line. It was emphasized in a previous study that the ADF contents of hays from different peanut varieties ranged between 29.60 and 39.11%, and there was a statistically significant difference between the varieties (Kokten, Kaplan, Seydesoglu, Ozdemir, & Boydak, 2014). The acid detergent lignin (ADL) content ranged between 0.43 and 2.62% in our study. The highest ADL content was obtained in Sultan variety and the lowest in Halisbey variety. In a study conducted on this subject, it was found that ADF contents of processed peanut stalks differed depending on the varieties and ranged between 43.8 and 59.4% (Oteng-Frimpong, Konlan, & Denwar, 2017).

The CC contents of peanut varieties and lines differed statistically significantly in this study (Table 3) and ranged between 1.69% and 5.29%. Campos-Mondragón et al. (2009) reported that the cellulose content of 6 different peanut varieties were between 3.0% and 4.4%; while Ibraheem, Kabeir, Mohammed and Bhagiel (2015) found it as 2.08%, and Shibli, Siddique, Raza, Ahsan and Raza (2019) between 4.95% and 8.53%. The recommended cellulose content for peanuts is 8.50% (Barbara et al., 2012). The content of hemicellulose (HC), which is the common name for some complex carbohydrates or polysaccharides found on the walls of plant cells together with cellulose and pectin, was found to be 2.40% on average, ranging between 1.97 and 2.69% in different peanut varieties and line.

Non-fiber carbohydrate (NFC) content, a value calculated with the equation NFC % = 100 - (NDF % + CP % + CO % + CA %), ranged between 16.26 and 34.86% depending on the varieties and line. Yang (2005) reported that NFC content of the peanut stover was 21.5%, while Yuan and Wan (2019) stated that the NFC content in the peanut shell was 11.2%.

Gas production is one of the most important indicators used in estimating the digestibility of feed stuff in the rumen of the ruminants (Yuan & Wan, 2019). A 24-hour in vitro gas production and methane production of different peanut varieties were found to be statistically insignificant. Various studies have been carried out on in vitro properties of peanut and its products (Rao, Tian, Fu, & Xue, 2018). Yang (2005) and Yuan and Wan (2019) stated that the gas production at the end of 48 h was 36.5 ml in the peanut shell. When the literature of in vitro studies on peanuts is reviewed, it is seen that some studies have been carried out on hays of peanut varieties. In a study examining the in vitro gas production in the silage of peanut stalks, Oteng-Frimpong, Konlan and Denwar (2017) found that the in vitro gas production of the stalks from 6 different peanut varieties did not differ depending on the varieties.

The metabolizable energy and NEL contents led to a difference among the varieties. In terms of metabolizable energy, the Sultan variety yielded the highest value with 12.30 MJ/kg, while the DA 2011-335 line yielded the lowest value with 10.30 MJ/kg. In a study conducted on this subject, it was determined that the ME values of processed peanut stalks did not lead to a difference between the varieties and ranged between 12.7 and 15.7 MJ/kg (Oteng-Frimpong, Konlan, & Denwar, 2017). The net energy lactation value ranged between 3.73 (DA 2011-335 line) and 4.13 (Cihangir variety) MJ/kg, revealing a statistically significant difference between the varieties and line.

Being a value calculated using the net gas production (GP), CP, and CA at the end of the 24-hour incubation period of 200 mg dry fodder sample; the organic matter digestibility (OMD) did not lead to a statistically significant difference between the varieties. In a study on this subject, it was found that the OMD values of the processed peanut stalks did not lead to a difference between the varieties (Oteng-Frimpong, Konlan, & Denwar, 2017).

Conclusions

The main purpose of this study was to determine the nutritional contents of six different peanut varieties and line, and to determine the metabolizable energy, net energy lactation, total digestible nutrients, and digestible energy values. From findings, the highest values were observed in Sultan variety in terms of CP, CO, ADF, NDF, ADL, CC, and ME; in Gazipasa variety in terms of NEL; in Cihangir variety in terms of HC; and in Gazipasa variety in terms of NFC. The 24-hour in vitro gas production and methane production, yet, did not lead to any difference between the varieties and lines.

Authors' contributions

TA contributed to the project idea, design and execution of the study. IU, ANC, VL and VT were in charge of laboratory analyses. TA and VP were responsible for supervision and writing the manuscript.

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Conflict of Interest Declaration

The authors have declared that no competing interest exists.

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