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PHYSICAL AND MECHANICAL PROPERTIES OF SOME PEANUT VARIETIES GROWN IN MEDITERRANEAN ENVIRONMENT

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ABSTRACT. Peanut is one of the most important oil crops in Turkey and grown mainly in Adana, Osmaniye and Aydın provinces. Five peanut cultivars (NC-V11, Halisbey, Arioglu 2003, Sultan and Osmaniye 2005), mostly grown in Turkey, were analyzed for the physical and mechanical characteristics of pods to select the most promising candidate. The average length, width, thickness, the geometric mean diameter, sphericity index and rupture force were studied. The results indicated that all the studied traits were varied significant among the varieties. Thus, a significant extent of genetic diversity was observed among the peanut cultivars under study. Shelling percentage values were varied between 65.7 - 71.6%. The highest shelling percentage was obtained at NC-V11 variety, while the lowest value was obtained at Sultan. The variety NC-V11, Halisbey, Arioglu 2003, Sultan and Osmaniye 2005 showed the average lengths of 42.27, 44.68, 46.17, 49.39 and 44.57 mm; width of 16.00, 17.90, 17.57, 17.45, and 17.92 mm; thickness of 17.33; 18.68; 18.54, 18.42, and 19.10 mm, respectively. Rupture force and stiffness values of peanuts depend on the cultivars and varied from 191.06 to 253.19 N and 129715.61 to 184954.67 N/m as higher and lower values, respectively. The varieties Arioglu 2003, Halisbey and Sultan have lower rupture force and stiffness values. On the other hand, NC-V-11 and Osmaniye-2005 varieties have higher value of rupture force and stiffness. These findings indicated that these two varieties need to more energy for hull rupture. But, in the same time, it played an important role for storage. The NC-V-11 variety achieved the highest values of rupture force than others. Some varieties had thick and strong hull, while some other had thin and weak.

Keywords: peanuts; stiffness; rupture force.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important oil and food crop. It is one of the world's major sources of vegetable oil and it ranks fifth in vegetable oil production, among nine

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major oilseed crops in the globe (FAO, 2013) and produced globally approximately 40 million tons (USDA, 2014). Peanut seeds are utilized as a snack food, direct human consumption or are processed to make peanut butter, oil, and other products (Çalışkan *et al.,* 2008). It is also an important source of farmers' cash income in countries where it is grown.

In Turkey, peanut is cultivated mainly in Adana, Osmaniye and Aydın provinces. Since the production of peanut in Turkey is not sufficient, it is only used as snacks and appetizers (Arıoğlu *et al.,* 2013). The knowledge of some important physical properties such as shape, size, and some mechanical properties (rupture force, stiffness) of grains is necessary for design of various separating, handling, optimum of threshing performance, processes of pneumatic conveying, storing and drying systems (Aydın, 2007). Therefore, this study aims to search the differencies the rupture force and stiffness of some peanut cultivars, mainly cultivated in Turkey.

The harvest of peanut and then crushed to remove the kernels and the processing of cracking peanut pod is the most critical operation to achieve high-quality kernels (Bagheri *et al.,* 2011). Many studies have reported on the physical properties of fruits, grains and seeds, such as cherry laurel fruits (Çalısır and Aydın, 2004), plum fruits (Ertekin *et al.,* 2006), jojoba fruits (Ince *et al.,* 2008), *Juniperus drupacea* fruits (Akinci *et al.,* 2004), bambara groundnuts (Baryeh, 2001). Although some researcher investigated the mechanical and physical properties of peanuts, such as some engineering properties of peanut and kernel (Aydın, 2007), physical properties of peanut hull pellets (Fasina, 2008), physical and mechanical properties of peanut protein film (Liu *et al.,* 2004). Improvement of cultivar in legumes for higher quantity and medicinally valuable compounds has been major priority in breeding programmes.

Identification of physical and mechanical traits of peanut as dimensional properties (rupture force, repose angle, bulk and true density) is essential in designing the characters of related machinery (Bagheri *et al.,* 2011). It should be noted that mechanical properties do not only constitute the basic engineering data required for machine and equipment design, but also they assist the selection of suitable methods for obtaining those data (Bagheri *et al.,* 2011). The determination of the rupture force decreased with the increase in moisture content in both vertical and horizontal loading positions (Olaniyan & Oje, 2002).

The major of researchers have interested on peanut kernels in their research area. However, the raw peanut has potentially a valuable hull, kernel, and shell, which can be subjected to industrial processing and economical evaluation. Therefore, it is an essential to make focus on the physical properties of peanuts as a whole product should be produced for an effective utilization (Akcali *et al.,* 2006). This study conducted to focuse mainly on rupture force and stiffness to rupture the peanut hull.

MATERIAL AND METHODS

This study was conducted at the Experimental Farm of the Çukurova University (41°04′N, 36°71′E, and 36 m elevation), Adana, Turkey, in 2009. The soil at the experimental area has formed as alluvial carried by the sub-branches of the river Seyhan. It has type A and C horizons, and has a mid-deep to deep structure. The ratio of organic materials decreases with depth. The soil has a loamy structure and its pH levels were in the range of 7.23-7.26. Its salt ratio is in the range of 0.052-0.060% levels. The useable P_2O_5 is approximately 14.32% at the top levels and decreases with depth. In addition, the nitrogen levels are approximately 0.143%, at the top levels, whereas it is approximately 0.062%, at deeper levels. Lastly, its lime levels are approximately 34.41%, at the top level, while it decreases with depth.

The seed bed was prepared by deep plowing, disking and loosening. Before the sowing, 200 kg ha^{-1} of 18-46-0 fertilizer (36 kg ha^{-1} N, 92 kg ha^{-1} P) and 2.0 l ha^{-1} of Traflen (Trifluralin), as herbicide, were applied. Five varieties of peanut, namely Halisbey, Sultan, NC-V11, Osmaniye-2005 and Arioglu 2003, were used in this experiment. The sowing of the varieties was done by hand with a depth of approximately 5 to 6 cm in the rows. In order to determine whether or not the peanut pods were ready for harvest, samples were gathered from the plots and mature pod ratios were determined through "shell-out" method (Kurt *et al.*, 2016).

At the harvest, the middle two rows of each plot were harvested by hand, while the outer two rows of each plot were discarded. In order to determine the size, 20 fruits were randomly selected. For each fruit, three principal dimensions, namely length, width and thickness, were measured by using a digital vernier caliper, with an accuracy of 0.01 mm, was used (Ince *et al.*, 2008).

Principal dimensions of the peanuts fruit: L= Length (Major Axis), W= Width (Intermediate Axis) and T= Thickness (Minor Axis). The geometric mean diameter (D_e), sphericity (ϕ) and arithmetic mean diameter (D_a) of the fruits were calculated using the following equations:

$$D_e = (LWT)^{\frac{1}{3}} \qquad (1)$$

$$\Phi = \frac{(LWT)^{\frac{1}{3}}}{L} \times 100 \qquad (2)$$

$$D_a = \frac{L + W + T}{3} \qquad (3)$$

Quasi-static compression tests were done with a Lloyd Material Testing Machine (model LRX Plus) equipped with a 5000 N load cell and computer. Two loading positions, which are parallel to the principal dimensions of the fruit, were used in the compression tests. Each sample was placed between two plates and compressed at 8 mm min^{-1} speed until the fruit was initiated. Rupture force was read directly from graphics. Each test was repeated 20 times (Ince *et al.*, 2017).

Shelling percent was measured according to the following formula: Shelling (%) = [weight of all seeds from 20 randomly selected pods/weight of 100 randomly selected pods] X 20) (Kurt *et al.*, 2016).

Statistical analysis was performed using SPSS 22 by One-Way ANOVA method. Treatment means were compared using Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Rupture force and stiffness values of peanuts depend on the cultivars and varied from 191.06 to 253.19 N and 129715.61 to 184954.67 N/m, as higher and lower values, respectively (*Table 1*). The maximum rupture force was recorded at NC-V11 type and the minimum was type of Sultan. On the other hand, stiffness varied between the NC-V-11 and Halisbey, as higer and lower values, respectively.

Table 1 - The physical parameters of selected peanuts

Cultivars	L	W	T	Dg	Æ	Da	Rupture force (N)	Stiffness (N/m)
NC-V11 (5)	42.27^{c}	17.32^{a}	17.33^{b}	22.68	1.31	25.2	253.19^{b}	184954.67^{b}
Arioglu 2003 (3)	44.68^{b}	17.90^{a}	18.68^{a}	18.68	1.32	27.09	200.04^{a}	134247.89^{a}
Halisbey (2)	46.17^{b}	17.57^{a}	18.54^{a}	24.65	1.33	27.43	214.02^{a}	129715.61^{a}
Sultan (4)	49.39^{a}	17.75^{a}	18.42^{a}	25.2	1.38	28.52	191.06^{a}	151445.55^{a}
Osmaniye-2005 (1)	44.57^{b}	17.92^{a}	19.10^{a}	24.64	1.31	27.04	249.77^{b}	177678.83^{b}

The literature review shows that there is no experimentation on estimation of rupture force in each of three main axes (length, width and thickness) of peanut kernel. This kind of knowledge can be helpful for energy saving during peanut handling (Bagheri *et al.,* 2011). In previous study, it was found for various crops the rupture force of kernel is highly affected by kernel moisture content (Polat *et al.,* 2006; Bagheri *et al.*, 2011). It is reported that there is an association between rupture force and kernel moisture content, with acheived the high values of coefficient of estimation. Furthermore, with increase of moisture, content the rupture force begins to decrease, might be due to soft and doughy condition of the kernels (Bagheri *et al.,* 2011). The small rupturing forces at higher moisture content might have resulted from the fact that the kernel tended to be very soft at high moisture content (Aydın, 2007). The length, width and thickness and geometric mean diameter of the black-eyed pea seeds were varied significantly and were influenced by moisture content (Altuntas & Demirtola, 2007).

The results in *Table 2* indicated that the differencies among the groups are significantly important (p<0,05). The fruit dimensions showed differencies at L and T values, but W values did not show any significant differencies (p<0,05).

Table 2 - Statistical analysis of five peanut varieties for fruit size

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
L	Between groups	7447.407	4	1861.852	185.127	0.000
	Within groups	452.572	45	10.057		
	Total	7899.979	49			
W	Between groups	2.463	4	0.616	0.568	0.687
	Within groups	48.798	45	1.084		
	Total	51.261	49			
T	Between groups	5411.346	4	1352.837	524.892	0.000
	Within groups	115.981	45	2.577		
	Total	5527.327	49			

L: Lenght; W: Width; T: Thickness

The results of the rupture force and stiffness of statistical tests are presented in *Table 3*. The results showed that the rupture force and stiffness differed in two groups. The varieties Arioglu, Halisbey and Sultan have lower rupture force and stiffness values. On the other hand, NC-V11 and Osmaniye-2005 varieties have higher value of rupture force and stiffness. This findings indicated that these two varieties need to more energy for hull rupture. But, in the same time, it played an important role for storage.

Table 3 - Statistical analysis of peanut fruits for stiffness and rupture force

ANOVA						
		Sum of squares	df	Mean square	F	Sig.
Rupture Force (N)	Between groups	65907.208	4	16476.802	6.344	0.000
	Within groups	249316.270	96	2597.044		
	Total	315223.477	100			
Stiffness (N/m)	Between groups	50699561319.275	4	12674890329.819	4.270	0.003
	Within groups	284938854986.649	96	2968113072.778		
	Total	335638416305.924	100			

The association between bulk density and moisture content was statistically significant in a similar experiment (Aydın, 2007). Limited investigations have been conducted on the physical properties of peanut. The different physical characters of sunflower were reported by Gupta & Das (1997). Some engineering properties of almond seeds, such as rupture strength, sphericity was reported by Kalyoncu (1990). It was reported that the moisture factor significantly influenced on the length, width, thickness, geometric diameter, mean volume and surface area (Azadbakht *et al.,* 2015). The increase in the moisture of grain cloud be causes weak hydrogen bonds of cellulose and reduction the ties among proteins, starch and other compounds, which reduces the mechanical strength of the grain (Khazaei *et al.,* 2004). Burubai *et al.* (2007) found that groundnut cultivars, which were studied, have the dimension as following: length, width, thickness, geometric diameter and mass from 12.60 to 24.85 mm, 5.35 to 11.25 mm, 4.40 to10.80 mm, 7.19 to 13.77 mm, and 0.22 to 1.17g, respectively. El-Sayed *et al.* (2001) observed that the average dimension values for length, width and thickness were 16.6762 mm, 11.5193 mm and 9.9805 mm of nutmeg, respectively.

A higher shelling percent indicated more seed weight and so it is preferable. Shelling percentage was statistically different among the different varieties. The differences among the peanut cultivars were statistically significant for the shelling percentage. The range of the shelling percentage was 65.7 to 71.6%. The highest shelling percentage was obtained at NC-V11 variety, while the lowest value was obtained at Sultan (*Fig.1*).

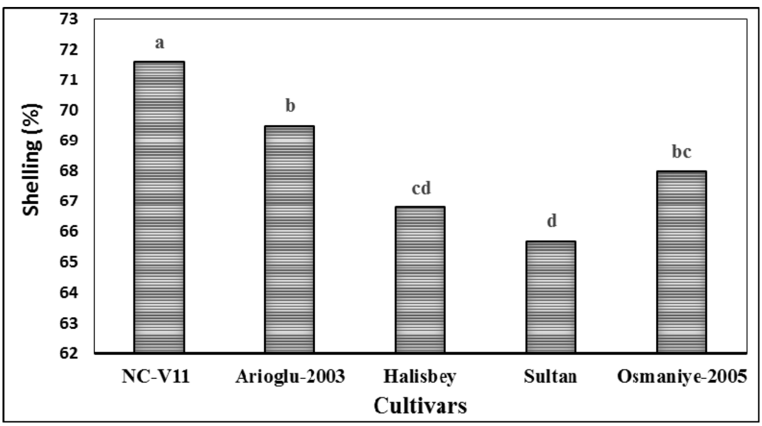

Figure 1 - Shelling percentage of the varieties of peanut

It is reported that shelling percentage is an important parameter for seed yield and has a highly significant negative correlation between pod volume and shelling percentage (Keisling *et al.,* 1982). Hartmond *et al.* (1996) observed that shelling percentage of the peanut lines was strongly influenced by germplasm lines and the largest pod lines gave the lowest shelling percentage among the lines. Significant variations between peanut cultivars and the shelling percentage was observed by Calıskan *et al.* (2008). Canavar & Kaynak (2013) found that the shelling percentage was increased by delaying the harvesting time.

CONCLUSION

After investigation of some mechanical and physical properties of peanut grain it can be concluded that the highest shelling percentage was obtain from NC-V11, while the lowest value was obtained from Sultan. Some cultivars had thick and strong hull, while some other had thin and weak. The NC-V11 and Osmaniye-2005 varieties achieved higher values of rupture force than other varieties. The future information about the rupture and stiffness tests could play a vital role to choose the cultivation of high quality genotypes.

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