www.ziraat.selcuk.edu.tr/dergi

Selçuk Üniversitesi
Ziraat Fakültesi Dergisi 20 (40): (2006) 32-36

PHYSICAL PROPERTIES AND NUTRIENT CONTENTS OF THREE EDIBLE SUMMER SQUASH (CUCURBITA PEPO L.) VARIETIES SEEDS

Cevat AYDIN[1] *Mustafa PAKSOY*[2]

[1] *Faculty of Agriculture, Department of Agricultural Machinery, Selçuk University, 42031 Konya, Turkey*

[2] *Faculty of Agriculture, Department of Horticulture, Selçuk University, 42031 Konya, Turkey*

(Corresponding author: E-mail:paksoy@selcuk.edu.tr)

ABSTRACT

Some physical properties and nutrient contents of three edible squash seed varieties (Çerezlik Kabak, Çerçevelik and Hanım Tırnağı, which are edible squash seeds local populations) were determined and compared in terms of linear dimensions, seed weight, thousand seed weight, volume, sphericity, projected area, true and bulk densities, porosity, repose angle, terminal velocity, rupture force, geometric mean diameter of edible squash seeds and kernel, dry matter, some minerals i.e. K, P, Ca, Mg, Na, Mn, Fe, Zn and Cu contents of kernels. All the properties of edible squash seeds and kernels that provide useful data to engineers in the design of processing machines were generally found to be statistically different in the three edible squash seeds populations. These differences could be attributed to the individual characteristics of these varieties and environmental and growing conditions.

Keywords: *Summer Squash; Cucurbita pepo L.; physical properties and nutrient contents*

BAZI YAZLIK KABAK TOHUMLARININ FİZİKSEL ÖZELLİKLERİ VE BESİN İÇERİKLERİ

ÖZET

Üç yazlık kabak çeşidi tohumunun fiziksel özellikleri ve besin içeriği belirlenmiştir. Bu çeşitlerde linear boyutlar, dane ağırlığı, 100 dane ağırlığı, dane hacmi, küresellik, izdüşüm alanı, dane yoğunluğu, yığın yoğunluğu, boşluk oranı, doğal yığılma açısı, kritik hız, zedelenme kuvveti, ortalama geometrik çap, kabuklu ve iç çekirdek için bazı nem düzeylerine bağlı olarak değişimleri ve K, P, Ca, Mg, Na, Mn, Fe, Zn ve Cu içerikleri belirlenmiştir. Araştırılan bu özellikler mühendislik hesaplamalarında ve bahçe bilimi çalışmalarında araştırıcılar için önemli temel veriler oluşturmaktadır.

Anahtar Kelimeler: *Yazlık kabak; Cucurbita pepo L.; fiziksel özellikler ve iç çekirdeğin besin içerikleri*

INTRODUCTION

Botanically, cucurbit kind including the squash vegetables is segmented in to three major catagories: *Cucurbita pepo* L. (summer squash), *Cucurbita moschata* Poir. (winter squash) and *Cucurbita maxima* Duch. (winter squash) (Vural *et al*, 2000). Edible squash seeds are produced from summer squash.

Squash is widely grown in Turkey. According to the Turkish Government Statistical data of 2003, vegetable production area is 1 040 204 ha represents 2.12% of total agricultural land. The vegetable production obtained from this area is 25 671517 tons. Total squash production is almost 340 000 tons and 1.54% of total fruit bearing vegetable production (SSI, 2003). There is no statistical data related to edible squash seed production (Vural *et al*, 2000).

Chemical and mineral composition of the seed is mainly important for human nutrition, whereas 100 g of consumable of squash fruit contains 1.4 g protein, 3.9g carbohydrate, 0.2g fat, 22 cal energy, 140 IU vitamin A, 0.07 mg B_1 (Thiamin), 0.04 mg B_2 (Riboflavin), 18 mg ascorbic acid (Vitamine-C), 0.6 mg niacin, 17 mg Ca, 38 mg P, 0.5mg Fe, 340 mg K (Vural *et al*., 2000). In addition, squash seeds contain 17.85% fat, 17.85% protein and 53.57% carbohydrate and moderate amounts seeds are rich in term of vitamin E. Squash seeds are consumed as appetizer, as they may be used for treatment of disease caused by parasites and prostate problems (Anonymous, 2003; Ekinci, 1972).

The number of 1 g seeds of squash varies from 2 to 5 seed. The seed starts to germinate at 10^{o}C, while the optimum germination fluctuates between 20-25^{o}C. The duration of germination period is between 4 to 8 days. In field condition, time of sowing is reliable after the late spring freezing with soil temperature above 10^{o}C. The squash is well grown under highly light condition. The vegetation period of summer squash is almost 100 days. The highest yield and seeds are obtained from soils that are deep, well-drained or permeable, high water holding capacity, high organics and mineral content. The desirable soil pH is between 6 and 7 (Vural *et al*. 2000). In general, surface irrigation methods are applied and sometimes dry farming is employed for edible squash production.

Squash is manually harvested. The threshing is usually carried out on hard floor with homemade threshing machine. In order to optimize various factors, threshing efficiency, pneumatic conveying, storage pertaining to squash seed, the physical properties are essential. The following edible squash seed local populations are cultivated in Turkey: Çerçevelik,

Hanım Tırnağı and Çerezlik Kabak etc. They differ from each other in some properties. A specific knowledge of the squash seed physical properties such as linear dimension (length, width, thickness), volume, weight, bulk density, terminal velocity, rupture force etc. and the variation between the squash seed population varieties is necessary to design of edible squash seed processing equipment. The functioning of many types of machines is influenced decisively by the size and shape of the seed participating, and so in order to study a given process should be described accurately. The volume and density of the seeds play an important role in numerous technological processes and in the evaluation of product quality. The terminal velocity plays also and important role in pneumatic transport of good and in cleaning foreign materials out of the same. In mechanical processing of the seeds, most of the damage occurs in the harvesting and threshing as well as mechanical conveying and other equipment. High force can cause to the seed damage and then, the damage is the failure in the final processing of the seed quality (Mohsenin, 1970; Sitkei, 1986).

However, detailed measurements of the principal dimensions of seeds and variations in physical and nutritional properties at various edible squash seeds population varieties have not been investigated. Many studies have been reported on the physical properties of other fruits, grains and seeds same as pumpkin and sunflower seeds (Joshi, et al.,1993; Gupta & Das, 1997). The terminal velocities were reported as follows: for lentil seeds at 11.0- 12.10 m/s, edible squash seeds at 4.37-6.57 m/s and soybean at 14.50 m/s (Çarman,1996; Paksoy and Aydın, 2004; Deshpande et al., 1993).

The aim of this study was to determine some physical and nutritional properties of the common edible squash population seeds, namely linear dimensions, seed weight and volume, sphericity, densities, porosity, projected area, angle of repose, terminal velocity and rupture force.

MATERIAL AND METHODS

Material

Three squash varieties (Çerezlik Kabak, Hanım Tırnağı, Çerçevelik, which are edible squash seeds local population) were used for all the experiments in this study. Samples were supplied from Beta Ziraat ve Ticaret A.Ş. and from the farmers in Nevşehir city were dried by being spread over the ground. The squash were cleaned in a cleaner air screen to remove foreign matter, and after being cracked, the kernels were separated from the shell by hand. Samples were kept in a refrigerator until analyses were performed. The initial moisture content of seeds was determined by using a standard method (USDA, 1970) and was found to vary between 6.46 and 7.13 % d.b. Reagents used for analyses were of analytical grade.

Method

Chemical analyses

The nutritional composition of edible squash seed was studied as explained below: dry matter of kernels was determined by drying the samples to a constant weight, in an oven at a temperature of 70^{o}C for 48 h before dry weight measured (AOAC, 1990). Samples were burned with a nitric acid and solution in a Microwave (CEM-Mars x 5 Model) system. The mineral contents in extracts was analyzed by ICP-AES (Varien- Vista Model). The amounts of minerals were calculated with a standard curve (Nymora et al., 1997).

Physical analyses

To determine the average size of the squash seed a sample of one hundred seeds was randomly selected. Measurement of the 3 major perpendicular dimensions at the seed were carried out with a micrometer to an accuracy of 0.01 mm.

The geometric mean diameter (D_p) of the seed was calculated by using the following relationship (Mohsenin, 1970):

$$D_p = (LWT)^{1/3} \qquad (1)$$

Where L is the length, W is the width and T is the thickness.

According to Mohsenin (1970), the degree of sphericity (Φ) can be expressed as follows:

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

This equation was used to calculate the sphericity of squash seeds in the present investigation.

To obtain the seed weight, each seed was weighed by a chemical balance reading to 0.001 g.

The kernel density of a seed is defined as the ratio of the sample weight of the seeds to the solid volume occupied by the same sample (Deshpande et al., 1993). The seed volume was determined using the liquid displacement method. Toluene (C_7H_8) was used rather than water because it is absorbed by seeds to a lesser extent. Also, its surface tension is low, so that it fills even shallow dips in a seed and its dissolution power is low (Sitkei, 1986; Ögüt, 1998). The bulk density is the ratio of the weight of a sample of a seed to its total volume. It is a moisture dependent property. The bulk density was determined with a weight per hectolitre tester which was calibrated in kg per hectolitre (Deshpande et al., 1993). The seed were poured in the calibrated bucket up to the top from a height of about 15 cm and excess seeds were removed by strike off stick. The seeds were not compacted in any way.

The porosity (ε) of bulk seed was computed from the values of kernel density and bulk density using the relationship given by Mohsenin (1970) as follows:

$$\varepsilon = \frac{\rho_k - \rho_b}{\rho_k} 100 \qquad (3)$$

Where ρ_b is the bulk density and ρ_k is the kernel density.

Projected area (P_a) was determined from the pictures of squash seeds which were taken by a digital camera (Kodak DC 5000), in comparison with the reference area to the sample area by using the Sigma Scan Pro 5 program.

The static natural angle of repose (Ø) was measured by using a plywood box, of 200 x 200 x 200 mm, which had a removable front panel. The box was filled with the samples and then the front panel quickly removed, allowing the seeds or kernels to flow and assume a natural slope (Joshi et al., 1993; Sitkei, 1986). The angle of repose was calculated by the measurement of the height (h) of the conical shape at the centre, and the radius (r) of the free samples over the surface.

$$Ø=\tan^{-1}(h/r) \qquad (4)$$

To determine the rupture force of seeds, biological material test device was used. The device developed by Aydın and Ögüt (1992) has three main components which are stable up and motion bottom of platform, a driving unit and the data acquisition system. The seed was placed on the stable up platform and pressed with motion platform. The rupture force of seed was measured by the data acquisition system.

Terminal velocity (Vt) was measured by using an air column. For each test, a sample was dropped into the air stream from the top of the air column, and air was blown up the column to suspend the material in the air stream. The air column was 33 mm diameter. The air velocity near the location of the fruit suspension was measured by a digital anemometer having a least count of 0.1 m/s (Paksoy and Aydın, 2004; Joshi et al., 1993; Sitkei, 1986).

RESULTS AND DISCUSSION

Nutrient contents

Nutrient contents of the three squash varieties were given in Table 1. As can be seen from Table 1, there were also differences in some mineral contents of the three squash varieties, at different significant levels ($p < 0.01$). Only dry matter contents of samples were not significant. The Al, Ca, Cu, Fe, K, Li, Mg, Ni, P, S, Se, V, Mn and Zn contents of samples were significantly different. From the Table 1. Çerezlik Kabak seeds results of nutrient contents were higher than the other squash seeds (Çerçevelik and Hanım-Tırnağı). Calcium (Ca) was found Hanım Tırnağı, Çerçevelik and Çerezlik kabak population varieties; 274.67, 331.00, 416.00 ppm, respectively. The highest value are obtained from Çerezlik kabak seed population. This difference is statisticaly significant. ($p<0.01$). Potasium (K) amounts was determined 6558.3 ppm, 8155.3 ppm and 8831.3 ppm for Hanım Tırnağı, Çerçevelik and Çerezlik kabak population seeds, respectively. The highest value are found from Çerezlik Kabak population seed. The other nutrient contents can be seen at Table 1.

Table 1. Nutrient contents of squash kernels

	Çerezlik Kabak	Çerçevelik	Hanım Tırnağı	LSD 0.01
Dry matter (%)	93.54	92.87	93.00	NS
Al (ppm)	6.63±0.07 a	4.81±0.01 c	5.49±0.08 b	0.109
Ca (ppm)	416.00±1.00 a	331.00±1.00 b	274.67±1.53 c	1.748
Cu (ppm)	12.29±0.09 a	10.65±0.13 b	10.28±0.29	0.338
Fe (ppm)	120.65±0.02 a	54.75±1.35 b	54.79±0.18 b	1.354
K (ppm)	8831.30±3.2 a	8155.30±2.1 b	6558.3±6.7 c	7.816
Li (ppm)	4.77±0.18 a	4.54±0.01 b	4.37±0.02 b	0.186
Mg (ppm)	2648.0±2.6 a	2497.0±1.0 b	2257.7 1.5 c	3.027
Ni (ppm)	1.84±0.01 a	0.50± 0.10 b	0.09± 0.01 c	0.102
P (ppm)	10474.0±17.0a	10379.0±8.0 b	7888.0±1.0	18.82
S (ppm)	3288.00±1.0 a	2292.0±6.1 c	2425.0±1.0 b	6.301
Se (ppm)	0.86±0.05 b	1.34v0.03 a	1.34±0.03 a	0.077
V (ppm)	16.96±0.01 a	16.32±0.01 b	12.76±0.02 c	0.006
Mn (ppm)	38.65±0.02 a	38.46±0.02 b	28.55±0.01 c	0.006
Zn (ppm)	55.21±0.02 a	37.44±0.10 c	41.95±0.03 b	0.056

All data represent the mean of three replicatios.
a,b,c letters indicate the statistical difference in rows.
NS: not significant.

Physical properties

Physical properties of the three edible squash seed varieties and their kernels were given in Table 2 and Table 3. As seen in Table 2 and Table 3, many physical properties of the seeds and kernels were found to be statistically significant with the exception that volume and porosity of seeds and seed weight and repose angle of kernels was found to be not significant ($p<0.01$). These differences could be the result of the individual properties of edible squash varieties, envi-

ronmental and growing conditions. Linear dimensions (length, width and thickness) and shapes (geometric mean diameter and sphericity) of the three edible squash seed varieties and its kernels were found to be statistically significant ($p < 0.01$). According to the results, the description, shape and size means of the Çerçevelik variety differ signiffi-cantly from the other varieties. Also, similar results were obtained for their kernels. These results should be considered specifically in the design of harvesting, threshing and separating mechanisms. Seed weight and thousand seed weight of seeds varied from 0.29 to 0.30 g and from 296.19 to 301.30 g, respectively.

These variations in seed weight and thousand seed weight were found to be significant ($p < 0.01$). Çerçevelik population variety had more weight (0.30 and 301.30 g respectively) than other varieties. Also, similar results were found with its kernel.

Volume of seeds was not fount statistically different. But, volume of kernel of Çerçevelik was more bigger than the other varieties ($p < 0.01$). Projected areas of seeds and its kernels were found to be statistically significant ($p < 0.01$).

Projected areas of seeds varied from 1.50 to 1.63 cm^2 and from 1.24 to 1.40 cm^2, repectively. These differences between the means of projected areas should be considered in the handling and processing the edible squash seeds, and in the evaluation of their quality.

True density, bulk density and porosity of the three varieties of seeds and kernels were found to be statistically significant at different probability ($p<0.01$). True density of seeds of Çerezlik Kabak was higher than the other varieties. But, true density of kernel of Çerçevelik was higher than the other varieties. Bulk density of seeds of Çerçevelik was determineted higher than the other varieties. But, bulk density of kernel of Hanım Tırnağı and Çerezlik Kabak were higher than Çerçevelik variety. Porosity of seeds was not found to be statistically significant. But, porosity of kernel of Çerçevelik was higher than the other varieties.

Table 2. Physical properties of squash seeds.

	Çerezlik Kabak	Çerçevelik	Hanım Tırnağı	LSD 0.01
Lenght (mm)	19.92±0.11b	21.77±0.67a	18.84±0.15c	0.701
Width (mm)	10.70±0.26b	11.55±0.50a	9.81±c	0.579
Thickness (mm)	2.56±0.03c	3.72±0.11a	3.12±0.07b	0.135
Seed weight (g)	0.29±0.01b	0.30±0.02a	0.29±0.01b	0.023
Thousand seed weight (g)	296.19±0.27b	301.30±0.61a	228.82±1.27c	1.462
Volume (cm^3)	0.73±0.01	0.76±0.01	0.75±0.01	NS
Geometric mean diameter (mm)	7.50±0.21b	7.63±0.15ab	7.73±0.02a	0.173
Sphericity (%)	43.36±0.32b	44.58±0.18a	44.36±0.05a	0.378
Projected area (cm^2)	1.50±0.1 b	1.63±0.01 a	1.60±0.01 a	0.063
True density (kg/m^3)	855.67±1.53a	736.44±0.14c	821.14±0.17b	1.748
Bulk density (kg/m^3)	714.00±1.00b	754.00±1.00a	414.00±2.65c	3.027
Porosity (%)	20.36±0.32	21.93±1.43	21.36±0.55	NS
Repose angle (^{o})	18.13±0.15b	20.00±1.00a	19.41±0.41a	1.105
Terminal velocity (m/s)	4.30±0.1a	4.10±0.10b	4.10±0.10b	0.174
Rupture force (N)	18.62±0.39c	20.13±0.15a	19.41±0.08b	0.436

All data represent the mean of three replicatios.
a,b,c letters indicate the statistical difference in rows.
NS: not significant.

Repose angle of seeds was found statistically significant ($p<0.01$). But, repose angle of kernels was not found to be statistically significant.

The terminal velocity of seeds of Çerezlik Kabak population variety was found higher than the other varieties. The terminal velocity of kernels of Çerçevelik was obtained higher than the other varieties. These differences in results can be attributed to the increase in mass of the individual seed or the kernel per unit when their frontal areas were presented to the air stream to suspend the material.

Rupture force of seeds and kernels were found to be statistically important ($p<0.01$). Rupture force of seeds and kernels of Çerçevelik variety was higher than the other varieties. For kernels, the mean values of the Çerezlik Kabak, Çerçevelik and Hanım Tırnağı varieties were in the 30.50–31.81 N ranges. Since Çerçevelik kernels have a hard structure and Çerçevelik seeds have a hard shell, a high force of 31.81 N for Çerçvelik kernels. The differences between the rupture forces of the squash seeds varieties should be considered in the design of specific machines for cracking, cleaning, separating, conveying, etc.

Several physical properties of the three squash varieties were described in order to design a speciffic machine for harvesting, threshing, conveying, cleaning, separating, storing, etc. For squash population varieties, many parameters were found to be signiffi-cantly different. Therefore, the differences between the physical properties of squash varieties should be

considered in squash seed mechanisation and food processing.

Table 3. Physical properties of squash kernel.

	Çerezlik Kabak	Çerçevelik	Hanım Tırnağı	LSD 0.01
Lenght (mm)	15.32 ±0.03 c	18.33±0.03a	17.75±0.05b	0.065
Width (mm)	9.15±.0.31b	10.39±0.10 a	9.45±0.18b	0.374
Thickness (mm)	2.66±0.04c	2.84±0.01a	2.74±0.06b	0.076
Seed weight (g)	0.25±0.01	0.26±0.01	0.26±0.01	NS
Thousand seed weight (g)	240.70±0.26b	245.93±0.81a	214.70±3.46c	3.594
Volume (cm^3)	0.39±0.01b	0.44±0.01a	0.37±0.02b	0.027
Geometric mean diameter (mm)	7.50±0.1b	7.74±0.05a	7.03±0.05c	0.128
Sphericity (%)	43.16±0.15b	43.26±0.21ab	43.41±0.08b	0.181
Projected area (cm^2)	1.24±0.01b	1.38±0.12a	1.40±0.10a	0.104
True density (kg/m^3)	784.00±1.00 c	811.00±1.00a	787.00±1.00 b	1.153
Bulk density (kg/m^3)	406.00±1.00ab	405.00±1.00b	406.67±0.58a	1.541
Porosity (%)	38.00±1.00b	39.80±1.31a	38.36±0.32b	1.119
Repose angle (^{o})	22.00±1.00	22.00±1.00	21.40±0.10	NS
Terminal velocity (m/s)	5.68±0.01b	6.10±0.10a	5.70±0.10b	0.143
Rupture force (N)	30.50±0.5c	31.81±0.45a	31.66±0.57b	0.078

All data represent the mean of three replicatios.
a,b,c letters indicate the statistical difference in rows.
NS: not significant.

REFERENCES

Anoniymous (2003). Available <http//www. herb data Pumpkin seeds, pepitas, squash seeds.htm>

AOAC (1990). Official methods of analysis (17th ed.). *Washington,DC: Association of Official Analytical Chemists.*

Aydin, C., Ögüt, H. (1992). Determination of deformation energy in some biological materials. *National Symposium on Mechanisation in Agriculture*, *Samsun, Turkey* (pp. 254-264).

Çarman, K. (1996). Some physical properties of lentil seeds. *Journal of Agricultural Engineering Research* 63, 87-92.

Deshpande, S. D., Bal, S., Ojha, T. P. (1993). Physical properties of soybean. *Journal of Agricultural Engineering Research* 56, 89-98.

Ekinci, S. (1972). Özel Sebzecilik. Ahmet Sait Matbaası. İstanbul.

Gupta, R. K., Das, S. K. (1997). Physical properties of sunflower seeds.*Journal of Agricultural Engineering Research* 66,1-8.

Joshi, D. C., Das, S. K., Mukherjee, R. K. (1993). Physical properties of pumpkin seeds. *Journal of Agricultural Engineering Research* 54, 219-229.

Mohsenin, N. N. (1970). Physical properties of plant and animal materials. *New York: Gordon and Breach Science Publishers.*

Nyomora, A.M.S., Sah, R. N., Brown, P.H. (1997). Boron determination in biological materials by inductively coupled plasma atomic emission and mass spectrometry: *effect of sample dissolution methods. Fresenius J. Anal Chem.* 357, 1185-1191.

Ögüt, H. (1998). Some physical properties of white lupin. *Journal of Agricultural Engineering Research* 56, 273-277.

Paksoy, M., Aydın, C. (2004). Some physical properties of edible squash (*Cucurbita pepo* L) seeds. *Journal of Food Engineering* 65, 225-231.

Sitkei, G. (1986). Mechanics of agricultural materials. Budapest*: Akademiai Kiado*.

SSI (2003). Agricultural statistics. *Ankara, Turkey.*

USDA (1970). Official grain standards of the United States. *US Department of Agricultural Consumer and Marketing Service Grain Division, Revised.*

Vural, H., Eşiyok, D., Duman, İ. (2000). Kültür Sebzeleri (Sebze Yetiştirme). *Egean University Pres Bornova, İzmir, Turkey*