*South Western Journal of* *Vol.2 , No.1, 2011*
*Horticulture, Biology and Environment* *pp.1- 13*
P-Issn: 2067- 9874, E-Issn: 2068-7958

# PHYSICO-CHEMICAL PROPERTIES OF APRICOT *(Prunus armeniaca* L.) KERNELS

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***Abstract.*** *The nutrients and physical properties of the five samples of apricot (Prunus armeniaca L.) kernels were determined in this study. Physical properties such as mass, length, width, thickness, geometric average diameter, sphericity, surface values, volume, bulk density, kernel density, porosity, terminal velocity, projected area and rupture strength, static coefficient of friction were determined at 2.98% (Çataloğlu), 2.18% (Hacıhaliloğlu), 2.46% (Hasanbey), 2.47% (Kabaaşı) and 3.25 % (Soğanoğlu) moisture content. Crude oil, dry matter, crude protein and crude fibre contents of apricot kernels were established between 28.26% to 42.48%, 96.75% to 97.82%,15.7% to 18.3% and 5.3% to 7.1%, 2.91 to 3.83%, respectively. Mineral content of apricot kernels collected from Malatya- Turkey were determined by an Inductively Coupled Plasma Atomic Emission Spectrometer (ASP-AES). All kernels contained high amounts Ca, K, Na and P. As a result, apricot kernel may be useful for the evaluation of nutritional information and oil source.*

***Key words****: apricot, kernel, oil, composition, physical properties*

## INTRODUCTION

Apricot *(Prunus armeniaca* L.) is classified under the *Prunus* species of Rosaceae family of the Rosales group. Apricot has an important place in human nutrition, and can be used as fresh, dried or processed fruit. Apricot kernels are used in the production of oils, benzaldehyde, cosmetics, active carbon, and aroma perfume (Yıldız 1994). Their kernels make an important contribution to the diet in many countries. They are used as vegetable (fresh fruit) and are a good source of protein, lipid, and fatty acids for human nutrition. The fatty acid composition of the endogenous fats plays an important role in determining shelf life, nutrition, and flavour of food products (Gao & Mazza 1995). Kernels of some apricots are sweet, and can be eaten as roasted and salted titbit. The most important apricot cultivars grown and used as sources for dried fruit are Çataloğlu, Çöloğlu, Hacıhaliloğlu, Kabaaşı and Hasanbey. In addition to these, Ordubat, Şam, Şalak, Şekerpare, Tokaloğlu and Teberze cultivars are used as table fruits varieties. Abd-Aal et al. (1985) and Khalil & Rahma (1986) determined that there is an important proportion of oil (50%) and other compounds such as benzaldehyde, surface active agents and proteins in Egyptian apricot kernels (Joshi et al. 1993). Beyer & Melton (1990) have studied the composition of New Zealand apricot kernels.

Kernels of apricot, peach, plum and almond belong to this family are produced as byproducts in tonnages from food canning industry. The kernels are considered as non-traditional potential resources for oils (Banerjee & Subrahmanyam 1985; Hassanein 1999). The cosmetic uses of the oil obtained from other *Prunus* kernels have already been determined and characterised particularly for apricot, peach, plum and cherry oils (Femenia et al. 1995, Johansson et al. 1997).

Food companies produce large amounts of preserved fruits at the expense of large amounts of waste. Several fruit seeds, such as cherry, apricot, citrus and apple can be used as sources of oils. The seed oils are already used for several purposes: blending with highly saturated edible oils to provide new oils with modified nutritional values, as ingredients in paint and varnish formulations, surface coatings and oleo-chemicals, and as oils for cosmetic purposes (Hauhout-Helmy 1990). Currently, large amounts of fruit seeds are discarded yearly at processing plants. This not only wastes a potentially valuable resource but also aggravates an already serious disposal problem. To be economically viable, however, both oil and meal from these fruit seeds must be utulized (Kamel & Kakuda 1992). To active the most economical and efficient utilization of these seeds, more information on the varieties, properties, and composition is required. Two main varieties of apricot kernels can be easily differentiated: sweet and bitter kernels (Femenia et al. 1995).

Some uses of apricot kernel oil in cosmetics and for medical purposes were reported by Hallabo et al. (1975). The possibility of mixing crude edible oil with crude fruit seed oils, such as apricot kernel oil, and then processing the oil mixture by the conventional methods of refining and bleaching was analysed by Hauhout-Helmy (1990).

Previous studies on some Rosaceae kernel oils had been reported by some authors (Hassanein 1999, Farine et al. 1986). Kernel oils of peach and apricot have been used as adulteratns or substitutes for some expensive oils particularly, almond oil (Egan et al. 1981).

The aim of this study was to determine the chemical and the physical properties of five apricot kernel cultivars (Soğanoğlu, Hacıhaliloğlu, Çataloğlu, Kabaaşı and Hasanbey) widely grown in Turkey.

## MATERIAL AND METHODS

### *Materials*

Five apricot cultivar kernels were obtained by hand processing from apricots growing in Malatya location of Turkey in August. Kernels were kept in glass jars until analyses at refrigerator. In all stages of trials, dry and mature kernels have been used.

### *Methods*

*Abreviations*

| | |
|---|---|
| *L* - length of apricot kernel (mm) | *Pk* - kernel density (kg/m$^3$) |
| *M* - mass of apricot kernel (g) | *l* - thickness of kemel(mm) |
| *ifi$_c$* - moisture content. (%) d.b. | *V* - volume of apricot kernel (mm) |
| *E* - porosity of apricot kernel (%) | *Vt* - terminal velocity (m/s) |
| $P_a$ - projected area (cm') | *W* - width of apricot kernel (mm) |
| *pb* - bulk density (kg/m$^3$) | *0* - sphericity of apricot kernel |

*Physical properties:*

All physical properties of kernels were determined using 20 repetitions at the natural moisture content of Soğanoğlu 3.25%, Hacıhaliloğlu 2.18%, Çataloğlu 2.98%, Kabaaşı 2.47% and Hasanbey 2.46% m.c.d.b.

To determine the size of the kernels, ten groups of samples consisting of 100 kernels have been selected randomly. Ten kernels have been taken from each group and their linear dimensions - length (L,) width *(W)* and thickness (T) and projected areas have been measured. Linear dimensions were measured by a micrometer to an accuracy of 0.01mm.

Projected area *($P_a$)* of kernels was determined by using a digital camera (Kodak DC 240) and Sigma Scan Pro 5 program (Trooien & Heermann 1992).

The Mass of kernels *(M)* were measured by an electronic balance to an accuracy of 0.001g.

The bulk density *(p^* was determined with a hectoliter tester which was calibrated in kg per hectoliter (Deshpande et al. 1993). The apricot kernels were dropped down into a bucket from a height of approximately 15 cm.The excess kernels were remored by sweeping the surface of the bucket. The kernels were not compressed in any way.

The kernels volume *(V)* and its kernels density *(pk),* as a function of moisture content, were determined by using the liquid displacement method. Toluene $(C_7H_8)$ was used instead of water because it is absorbed by grains to a lesser extent. Also, its surface tension is low, so that it fills even shallow dips in a kernel and its dissolution power is low (Singh & Goswami 1996).
The porosity (ε) was determined by the following equation:

$$(1)\quad e = l - pt/Pk$$

In which $p_b$ and *pk* are the bulk density and the kernel density, respectively (Thompson & Isaacs 1967).

The rupture strength values of apricot kernels were measured by forces applied through three axis (length, width and thickness). The rupture strength of kernels, were determined with Test Instrument of Biological Materials (Figure 1) using the procedure described by Aydın and Öğüt (1991). The device, has three main components which are stable up and motion bottom of platform, a driving unit (AC electric motor and electronic variator) and the data acquisition (Dynamometer, amplifier and XY recorder) system. The rupture force of kernel was measured by the data acquisition system. The kernel was placed on the moving bottom platform and was pressed with stationary platform. Experiment was conducted at a loading velocity at 50 mm $min^{-1}$.

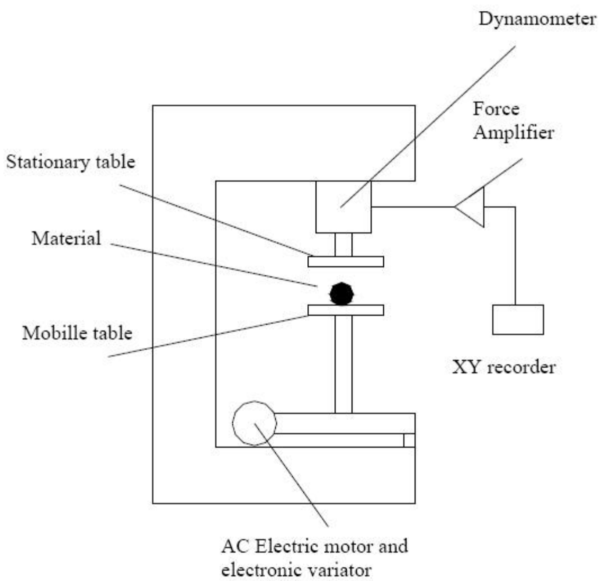


Figure 1. Biological material tets unit (B.M.T.U.)

The terminal velocities $(V_t)$ of kernel at natural moisture content were measured using an air column. For each test, a sample was dropped into the air stream from the top of the air column, up which air was blown to suspend the material in the air stream. The air velocity near the location of the kernel suspension was measured by electronic anemometer having a least count of 0.1 m/s (Hauhout-Helmy 1990; Joshi et al. 1993).

Geometric mean diameter $(D_g)$ and sphericity $(Ø)$ values were found using the following formula (Mohsenin 1970; Jain & Bal 1997).

$$(2) D_g = (LWT)^{0.33} 3$$

$$(3) \quad Ø = (LWT)^{0.33} 3/L$$

The coefficient of static friction was measured by using sheet iron, galvanized sheet iron and wood surfaces. For this measurement one end of the friction surface is attached to a endless screw. The kernel was placed on the surface and it was gradually raised by the screw.

Vertical and horizontal height values were read from the ruler when the apricot kernel started sliding over the surface, then using the tangent value of that angle the coefficient of static friction was found. Baryeh (2001), Dutta et al. (1998), Suthar and Das (1996) have used similar methods.

*Chemical analyses:*

The some chemical compositions (moisture, crude fiber, crude oil, crude protein and crude ash) were analyses according to AOAC (1984). Samples were homogenized and subjected to extraction for 6 h with petroleum ether (boiling range 30-60 °C) in a Soxhlet apparatus. The extracted oil was dried over anhydrous sodium sulphate and the solvent was removed under reduced pressure in a rotary film evaporator. Oil percentages were determined by weight difference. Ash was determined in a muffle furnace at 900 °C for 8 h (Demir & Özcan 2001). The nitrogen content estimated by the Kjeldahl method and was converted to protein content by using the conversion factor 6.25. The fiber and moisture were determined according to Demir and Özcan (2001).

*Determiation of mineral contents:*

About 0,5g of dried and ground apricot kernel was put into burning cup with 15 ml of pure $HNO_3$. The sample was incinerated in a MARS 5 microwave oven at 200 °C. Distilled deionized water and ultrahigh-purity commercial acids were used to prepare all reagents, standards, and walnut samples. After digestion treatment, samples were filtrated through whatman No 42. The filtrates were collected in 50 ml Erlenmayer flasks and analysed by ICP-AES. The mineral contents of the samples were quantified against standard solutions of known concantrations which were aralyzed concurrently (Skujins 1998).

*Working conditions ofICP-AES:*

Instrument: ICP-AES (Varian-Vista)
RF Power: 0,7-1,5 kw (1,2-1,3 kw for Axial)
Plasma gas flow rate (Ar): 10,5-15 L/min. (radial) 15 " (axial)
Auzilary gas flow rate (Ar): 1,5 "
Viewing height: 5-12 mm
Copy and reading time: 1-5 s (max. 60 s)
Copy time: 3 s (max. 100 s)

*Statistical analyses:*
Results of the research were analysed for statistical significance by analysis of variance (Salem& Salem 1973). This research was performed by three duplicates with a replicate.

## RESULTS AND DISCUSSION

### *Physical properties*

The mass, length, width, thickness, geometric average diameter and sphericity values of the apricot kernels were given in Table 1. The frequency distributions of these kernels with respect to dimensional properties were determined.

Table 1. Dimensional properties of apricot kernels.

| Properties | Cultivars | | | | |
|---|---|---|---|---|---|
| | Çataloglu | Hacihahloglu | Hasanbey | Kabaaşı | Sogancı |
| Moisture content, (%) db. | 2.98 | 2.18 | 2.46 | 2.47 | 3. 25 |
| Mass, (g) | 0.49±0.007 | 0.45±0.006 | 0.58±0.007 | 0.49±0.0OS | 0.46±0.005 |
| Length, (mm) | 17.09±0.11 | 17.2±0.1O | IS.44±0.08 | 17.07±0.13 | 13.96±0.06 |
| Width, (mm) | 9.32±0.06 | 8.98±0.05 | 10.30±0.58 | 9.81±0.08 | 10.69±0.05 |
| Thickness, (mm) | 6.37±0.05 | 6.19±0.04 | 5.62=0.04 | 5.56±0.05 | 6.23±0 05 |
| Geo. Me. Dia, (mm) | 10.04±0.05 | 9 85±0.04 | 10.2I±0.04 | 9 75±0.06 | 9 75±0.04 |
| Sphericity | 0.59±0.003 | 0 57±0.003 | 0 55±0.002 | 0.57±0.003 | 0 69±0.002 |

At 2.98 % moisture level, 96% of Çataloğlu apricot kernels were between 0.35g and 0.60g in weight, 95% of those were between 15mm and 18.50 mm in length, 93% of those between 8.50 and 10 mm in width, and 96% of those between 5.50 mm and 7 mm in thickness. By establishing *L/W, L/T, L/M, L/0* and *L/Dg* relationships between length, width, thickness, mass, sphericity and geometric average diameter values has been determined. This relationship was found to be as the follows.

*L=1.834xW=* 2.683x T=34.180xM= 28.966x *Ø=1.702xDg*

At 2.18 % moisture level, 97% of Hacıhaliloğlu apricot kernels were between 0.35g and 0.55g in weight, 93% of those were between 15.5mm and 18.50 mm in length, 96% of those between 8 mm and 9.5 mm in width, and 93% of those between 5.5 mm and 7 mm in thickness. By establishing *L/W, L/T, L/M, L/0* and *L/Dg* relationships between length, width, thickness, mass, sphericity and geometric average diameter values has been determined. This relationship was found to be as the follows.

*L=1.916xW=* 2.780x T=38.240xM= 30.192x Ø=1.747xDg

At 2.46% moisture level, 94% of Hasanbey apricot kernels were between 0.45g and 0.68g in weight, 96% of those were between 16.50 mm and 19.50 mm in length, 98% of those between 8.77 mm and 11 mm in width, and 98% of those between 4.5 mm and 6 mm in thickness. By establishing *L/W, L/T, L/M, L/0* and *L/Dg* relationships between length, width, thickness, mass, sphericity and geometric average diameter values has been determined. This relationship was found to be as the follows.

*L=1.790xW=* 2.283x T=31.793xM= 33.527x Ø=1.793xDg

At 2.47% moisture level, 98% of Kabaaşı apricot kernels were between 0.35g and 0.70g in weight, 97% of those were between 14.5mm and 19 mm in length, 97% of those between 8.5 mm and 11 mm in width, and 98% of those between 4.5 mm and 6.5 mm in thickness.

By establishing *L/W, L/T, L/M, L/0* and *L/Dg* relationships between length, width, thickness, mass, sphericity and geometric average diameter values has been determined. This relationship was found to be as the follows.

L=1.741xW= 3.072x T=34.857xM= 29.965x *Ø=1.752xDg*

At 3.25% moisture level, 96% of Soğanoğlu apricot kernels were between 0.35 g and 0.50 g in weight, 95% of those were between 12.5mm and 14.5 mm in length, 95% of those between 10 mm and 11.75 mm in width, and 99% of those between 5 mm and 7 mm in thickness. By establishing *L/W, L/T, L/M, L/0* and *L/Dg* relationships between length, width, thickness, mass, sphericity and geometric average diameter values has been determined. This relationship was found to be as the follows.

*L=l.3O6xW=2.24lxT=3O.347xM=\9.942x0=lA3OxDg*

The dimensional properties of apricot kernels used in the experiments were given in Table 2. It was found that *L/T* relationship in Hacıhaliloğlu was statistically meaningful at 5% level. *L/T* relationship in Hasanbey, Kabaaşı, Çataloğlu and Soğanoğlu apricot kernel types were statistically not meaningful. It was found that *L/W, L/M, L/0* and *L/Dg* relationships in Apricot type kernels: the whole relationships were statistically meaningful at 1% level.

The volume, bulk density, kernel density, porosity, terminal velocity, projected area, rupture strength and static friction coefficent values of apricot pits were given in Table 3. According to these results, çataloğlu type apricot kernel has the highest volume with 0.58 $cm^3$. It was followed by Soğanoğlu, Hasanbey, Kabaaşı, and Hacıhaliloğlu type apricot kernels. The highest bulk density value, 574.62 $kg/m^3$, was found in Hacıhaliloğlu types; and it was followed by hasanbey, Kabaaşı, Çataloğlu and Soğanoğlu types. The highest kernel density value, 1117.02 $kg/m^3$, was found in Hasanbey types, and it was followed by Kabaaşı, Hacıhaliloğlu, Çataloğlu, and Soğanoğlu types. The highest porosity value was found to be 49.95 % in Hasanbey type; and the lowest porosity value was found

Table 2. Tlıe correlation coefficient of apricot kernels.

| Cultivars | Partıculai's | Ratıo | Degrees of freedom | Correlation coefficient |
|---|---|---|---|---|
| Çataloğlu | *L/W* | 1.834 | 98 | 0.614** |
| | *L/T* | 2 .683 | 98 | 0.095 |
| | *L/M* | 34.180 | 98 | 0.7526** |
| | *L/Ø* | 28.966 | 98 | -0.641** |
| | *L/Dg* | 1.702 | 98 | 0.721** |
| Hacıhaliloğlu | *L/W* | 1.916 | 98 | 0.685** |
| | *L/T* | 2.780 | 98: | 0.157* |
| | *L/M* | 33.24 | 98 | 0.798** |
| | L/Ǿ | 30.192 | 98 | -0,615** |
| | *L/Dg* | 1.747 | 98 | 0.775** |
| Hasanbey | *L/W* | 1.790 | 98 | 0.580** |
| | *L/T* | 2.283 | 98 | 0.148 |
| | *L/M* | 31.793 | 98 | 0.746** |
| | *L/Ǿ* | 33.527 | 98 | -0.411** |
| | *L/Dg* | 1.793 | 98 | 0.707** |
| Kabaaşı | *L/W* | 1.741 | 98 | 0.760** |
| | *L/T* | 3.072 | 98 | 0.129 |
| | *L/M* | 34.857 | 98 | 0.807** |
| | *L/Ǿ* | 29.965 | 98 | -0.627** |
| | *L/Dg* | 1.752 | 98 | 0.808** |
| Soğancı | L/W | 1.306 | 98 | 0.525** |
| | L/T | 2.241 | 98 | 0.140 |
| | L/M | 30.347 | 98 | 0.758** |
| | L/Ø | 19.942 | 98 | -0.525** |
| | L/Dg | 1.432 | 98 | 0.661** |

**P>0.01; * P>0.05

to be 39.98 % in Soğanoğlu type. The highest terminal velocity value was found to be 6.31 m/s in Hacıhaliloğlu type; and the lowest terminal velocity value was found to be 5.82 m/s in Hasanbey type. Again, the highest projected area value was found to be 1.60 $cm^2$ in Hasanbey type; and the lowest projected area value was found to be 1.13 $cm^2$ in hacıhaliloğlu type. The highest static friction coeffıcent value was found to be 0.516 in Hasanbey type on wooden surfaces; and the lowest static friction coefficent value was found to be 0.275 in Çataloğlu type on galvanized sheet. The rupture strength values found to be the highest at the thickness dimension in all types. The shear force values at length dimension and width dimension followed this highest value in all types except Çataloğlu types. This difference in Çataloğlu type stems from type difference.

Table 3. Some physical properties of apricot kernels.

| Properties / Cultivars | Çataloğlu | Hacıhaliloğlu | Hasanbey | Kabaaşı | Soğanoğlu |
|---|---|---|---|---|---|
| Volume ($cm^3$) | 0.58±0.04 | 0.45±0.02 | 0.49±0.02 | 0.47±0.03 | 0.51±0.02 |
| Bulk density ($kg/m^3$) | 561.16±5.48 | 574.62±10.13 | 571.94±6.22 | 564.74±4.74 | 555.45±2.03 |
| Kernel density ($kg/m^3$) | 961.57±39.07 | 1023.15±23.43 | 1117.02±35.5 | 1088.6±28.51 | 930.89±34.56 |
| Porosity (%) | 43.01±1.51 | 43.81±1.13 | 49.95±1.36 | 48.15±1.38 | 39.98±1.41 |
| Terminal velocity (m/s) | 6.27±0.17 | 6.31±0.16 | 5.82±0.14 | 6.28±0.22 | 6.18±0.12 |
| Projected area ($cm^2$) | 1.29±0.03 | 1.13±0.03 | 1.60±0.08 | 1.42±0.06 | 1.25±0.02 |
| Rupture strength | | | | | |
| Length | 46 ±0.90 | 40.17±4.19 | 43.55±2.51 | 47.31±1.68 | 49.55±1.88 |
| Width | 43.17±1.88 | 53.18±3.39 | 55.60±3.95 | 61.05±2.19 | 60.06±3.34 |
| Thickness | 87.22±12.44 | 94.55±9.12 | 155.13±15.69 | 125.35±16.17 | 114.02±11.15 |
| The coefficient static friction | | | | | |
| Sheet iron | 0.478±0.022 | 0.429±0.014 | 0.439±0.010 | 0.443±0.015 | 0.436±0.010 |
| Galvanized sheet iron | 0.275±0.010 | 0.291±0.13 | 0.314±0.011 | 0.287±0.010 | 0.321±0.011 |
| Wood | 0.492±0.024 | 0.461±0.025 | 0.516±0.036 | 0.474±0.022 | 0.505±0.037 |

***The chemical properties***

The composition of the five apricot cultivar kernels investigated is presented in Table 4. The cultivars showed relatively low differences. For the production of apricot juice of good quality, Soğanoğlu, Hacıhaliloğlu, Çatalağlu, Kabaaşı and Hasanbey are ideal cultivars. So, they have high contents of kernel as by apricot product. In the present investigation kernel material of apricot from Malatya were investigated regarding the some chemical composition as well as the mineral contents.

Crude protein, crude oil, crude fibre, ash and dry matter contents of all fruits were determined between 15.7 to 18.3%, 28.26 to 42.48%, 15.3 to 17.1%, 2.91 to 3.83% and 96.75 to 97.82%, respectively. The protein, fibre and ash values of several kernels were found partly similar, having protein contents in a narrow range. The ash contents of apricot kernels established between 2.91% (Hacıhaliloğlu) to 3.83% (Çataloğlu). Özcan (2000) determined oil (46.30-51.40%), crude protein (23.58-27.70%), crude fibre (13.49-17.98%), moisture (4.91*6.66%) and ash (2.10-2.67%)

Table 4. Some chemical composition of several apricot kernels

| Properties | Cultivars | | | | |
|---|---|---|---|---|---|
| | Soğanoğlu | Hacihaliloğlu | Çataloğlu | Kabaaşı | Hasanbey |
| Moisture, (%) | 3.25±0.73 | 2.18±0.27 | 2.98±0.31 | 2.47±0 17 | 2.46±0.41 |
| Crude oil, (%) | 41.77±1.13 | 42.43±2.32 | 30.82±1.97 | 28 26±1.13 | 29.47±1.74 |
| Crude protein (%) | 18.3±1.27 | 17.6±1 21 | 16.3±1.11 | 15 7±1.32 | 16.1 ± 1. 74 |
| Crude fibre, (%) | 15.7±2.14 | 15.3±1.81 | 16.2±1.19 | 17 1±2 07 | 16.3±1.63 |
| Crude ash, (%) | 3.27±0.74 | 2.91±0.18 | 3.83±0.27 | 3.48±0.31 | 3.71±0.63 |

contents of four apricot kernels collected from Malatya provinces. Protein and oil concentrations of all kernels are low from Amar (24.1% and 50.9%) and Moorpark (20.6% and 52.0%) by Abd-Aal et al.(1986a,b). Salem and Salem (1973) reported 53.17% and 55.96% oil in Egyptian (sweet) and Egyptian (bitter) apricot kernels, respectively. Also, Joshi et al.(1993) established 3.4% moisture, 44.6% oil, 20.2% protein, 18% fibre and 2.3% ash in Chavaru apricot kernel. Mineral contents of kernels are given in Table 5. Ca, K, Mg, Na and P were established as major minerals in kernels. Others were determined at minor levels. The phosphor levels of kernels ranged between 4967.5 (Kabaaşı) and 9387.2% ppm (Soğanoğlu). The highest minerals were K, P and Ca. Potassium contenst was found the highest (91909.4 ppm) in Soğanoğlu kernel. In a previous study, mean mineral contents of apricot kernel varieties were found to be between 2.75 -3.68% for Na, 1.06-2.94 ppm for P and 0.35 - 0.64 ppm for K (Özcan 2000). The K, Na, Ca, P and Mg levels are adequate.

Moisture, crude oil, crude protein, crude fibre and crude ash values and mineral contents in apricot kernels are affected mainly by variety. As a result, the present study showed the kernels of the researched species of *Prunus* fruits from Turkey to be a potential source of valuable oil which might be used for edible and other industrial applications. In addition, knowledge of the mineral contents, as kernels is of great interest. Due to limited number of samples determined in this work, this conclusion should be verified several apricot kernel samples. Future work also consider other compounds and antinutrient factors of these and another apricot kernels which may be used as food. So, sweet kernels can be used as baked products and roasted titbits.

Table 5. Mineral contents of several apricot kernels.

| Cultivars | Al | Ca | B | Cr |
|---|---|---|---|---|
| Çataloğlu | 87.3± 6.5 | 1689.4±463.8 | 138.8±26.1 | 3.5±2.7 |
| Soğanoğlu | 64.3±7.0 | 2909.6±137.3 | 117.7±49.4 | 5.7±5.3 |
| Kabaali | 55.0±2.4 | 1617.4±144.0 | 123.4±24.5 | 3.7±2.0 |
| Hacıhaliloğlu | 38.8±10.0 | 2507.0±109.6 | 97.9±49.6 | 4.3±0.2 |
| Hasanbey | 55.9±1.5 | 1344.5±112.4 | 134.1±9.3 | 5.2±2.2 |

| Cultivars | Cu | Fe | K | Mg | Mn |
|---|---|---|---|---|---|
| Çataloğlu | 14.1±1.7 | 37.9±4.4 | 12910.0 ±103.3 | 1505.6±78.8 | 6.5±0.4 |
| Soğanoğlu | 22.0±2.1 | 40.5±12.7 | 91909.4±860.9 | 1960.1±53.2 | 14.4±7.4 |
| Kabaali | 10.8±0.9 | 33.4±0.9 | 11055.1±115.5 | 1475.7±34.2 | 7.6±1.0 |
| Hacıhaliloğlu | 21.1±1.9 | 45.2±13.9 | 15495.7±789.2 | 1868.2±50.1 | 10.4±5.0 |
| Hasanbey | 10.3±0.0 | 30.2±4.4 | 11090.0±581.8 | 1323.7±29.1 | 8.3±0.0 |

| Cultivars | Na | Ni | P | Zn |
|---|---|---|---|---|
| Çataloğlu | 1076.5±8.7 | 0.6±0.1 | 5681.4±29.4 | 51.3±15.5 |
| Soğanoğlu | 1344.7±43.9 | 4.5±2.7 | 9387.2±51.6 | 60.7±9.0 |
| Kabaali | 738.7±96.2 | 1.0±0.3 | 4967.5±48.2 | 44.7±9.9 |
| Hacıhaliloğlu | 1186.7±72.7 | 1.9±1.7 | 8213.5±44.2 | 51.0±26.7 |
| Hasanbey | 964.9±17.6 | 2.2±0.3 | 5227.7±81.8 | 51.9±2.7 |

**ACKNOWLEDGEMENT.** This work was supported by Selçuk University Scientific Research Project (S.U.-BAP. Konya-Turkey).

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