SOME PHYSICAL PROPERTIES OF APRICOT PITS

ABSTRACT
The physical properties of apricot pits and apricot kernel are necessary for the design of equipments for processing, transportation, sorting, and breaking. In this study, some physical properties of pits and kernels were evaluated as function of moisture content varying from 8 to 19 % for apricot pits and 24 % for apricot kernels. Apricot pits, in this moisture range, pit length, width, thickness and geometric diameter increased from (20.81 to 22.53 mm), (17.44 to 18.02 mm), (11.38 to 11.66 mm) and (15.9 to 16.1 mm), respectively, the projected area increased from 2.90 to 3.21 cm², the porosity increased from 49 to 58 %, the volume increased from 0.16 to 0.17 cm³, the mass increased from 1.75 to 1.84 g, bulk and true densities increased from 507 to 570 kg/m³ and 1020 to 1160 kg/m³ respectively, the rupture force of apricot pits decreased from (1397.9 to 581.4 N), (1177.2 to 341.97 N) and (632.94 to 186.39 N) at X, Y and Z axes respectively, the angle of repose increased from 32.6 to 40.49º and the coefficient of static friction increased from (0.41 to 0.77), (0.65 to 0.80), (0.43 to 0.55), (0.40 to 0.51) and (0.22 to 0.26) for cardboard, rubber, wood, iron and glass respectively.

The apricot kernels, dimension properties (length, width and thickness) were 15.29, 10.41 and 5.27 mm respectively, the mass was 0.48 g, the volume was 0.62 cm³, the bulk and true densities were 497 and 840 kg/m³ respectively, the geometric diameter was 9.32 mm, the sphericity was 59 % and the porosity was 42 %.

INTRODUCTION
Apricot (Prunus armeniaca L.) is classified under the prunus species of Prunaidea sub-family of the Rosaceae family of the Rosales group. Apricot has an important role in human nutrition and apricot fruits can be used as fresh, dried or processed fruit. It can be made into juice, marmalade, jam, and jelly. (Gezer et al., 2002)
The apricot kernel contains 17.38% protein, 48.70% crude oil, 3.68% Na, 1.06 ppm P, 0.58 ppm K, 0.11 ppm Ca, 0.24 ppm Mg, 42.8 ppm Fe, 42.35 ppm Zn, 1.10 ppm Mn, 2.09 ppm Cu (Özcan 2000).

Apricot kernel contains 40% oil which is composed of 30% linoleic acid (C18:2) and 60% oleic acid (C18:1). Linoleic acid is an essential fatty acid. Essential fatty acids and their longer chain-molecular products are necessary for maintenance of growth and reproduction (Eastwood, 1997).

The stone of apricot are used in the production of oils, Benz al de Hyde, cosmetics, active carbon, aroma perfume, and food after remove glycoside amygdaline, (Vursavus and Faruk 2004).

In Egypt the annual production apricot about 78500 tons apricot stone from this production, Most of the apricots are produced in Al-Qulybia and Al-Fayome. (FAO2007).

Important applications of activated carbons are related to their use in water and industrial wastewater treatment for removal of flavor, color, odor and other undesirable organic impurities. Activated carbon has found increasing application in the field of hydrometallurgy, especially in the recovery of gold and silver from cyanide solutions (Dorbrowksi 2001).

Mohsenin (1970) reported that the physical properties of materials such as, shape, size, volume and surface area are important in many problems associated with design or development of a specific machine, analysis of the behavior of the product in handling of material, stress distribution in the material under load.

Kaleem et al. (1993) reported that the angle of repose is very important in determining the inclination angle of the machine hopper tank.

Deshpande et al. (1993) found that the surface area of soya bean grain increased from 81.3 to 95.2 mm², when the moisture content was increased from 8.7 to 25 % w.b.
GÜner et al. (2004) reported that rupture strength values of apricot pit and apricot kernel, respectively. Rupture strength values of apricot pit and apricot kernel decreased as the moisture content increased.

Gezer et al. (2002) reported that, various some physical properties of pits and kernels of Hacıhaliloglu apricots were evaluated as a function of moisture content varying from 6.79% to 36.19% d.b. for apricot pits and from 6.95% to 38.76% d.b. for apricot kernels.

In apricot pits, dimensional properties and weight increased; the sphericity decreased from 0.6537 to 0.6526; the thousand grain mass increased from 1720 to 2028 g; bulk density increased from 463 to 581 kg/m³, grain volume increased from 1626 to 1746 mm³, volume weight increased from 1053 to 1161 kg/m³, terminal velocity increased from 7.11 to 7.76 m/s; the projected area increased.

From 2.985 to 3.539 cm², the porosity increased from 43.96% to 50.03%; the rupture strength of apricot pits decreased from 514.03 to 315.89 N; and the coefficient of static friction of apricot pits increased as the moisture content increased.

In apricot kernels, however, dimensional properties and weight increased; the sphericity increased from 0.5879 to 0.7164; the thousand grain mass increased from 473 to 616 g; bulk density decreased from 559 to 545 kg/m³, grain volume increased from 497 to 573 mm³, true density increased from 1003 to 1094 kg/m³, terminal velocity increased from 5.37 to 6.68 m/s; the projected area increased.

From 1.293 to 1.519 cm², the porosity decreased from 55.70 % to 49.70 %; rupture strength of apricot kernels decreased from 63.28 to 44.13 N; and the coefficient of static friction increased as the moisture content increased.

Baryeh (2000) found that the volume variation with moisture content.

The volume increases with moisture content from 425 mm³ at 5% moisture content to 900 mm³ at 25% moisture content. After 25% moisture content, the volume changes very little. He added that the variation of the angle of repose with moisture content, The angle of repose increases non-linearly with grain moisture content from 19.8° at
5% moisture content to 23.5° at 20% moisture content and decreases gently thereafter to 21° at 35% moisture content

Vursvus and Faruk (2004) reported that, various physical properties of apricot pits were evaluated as a function of moisture content varying from 6.38% to 39.33% d.b. for apricot pits and from 6.59% to 41.46% d.b. for apricot kernels.

In apricot pits, the average length increased from 28.89 to 31.20 mm, the average the width increased from 15.92 to 17.43 mm and the average the thickness increased from 9.96 to 10.75 mm. They added that by increasing moisture content the thousand grains mass increased from 1950 to 2590 g.

In apricot kernels, the average length increased from 19.17 to 20.69 mm, the average width increased from 9.99 to 10.43 mm and the average thickness increased from 5.74 to 7.08 mm. They added that by increasing moisture content the thousand grains mass increased from 480 to 650 g.

Aydin (2002) reported that the porosity of hazel nut depend on the bulk as well as true densities; the magnitude of variation in porosity depends on these factors only. The porosity of nut was found to slightly increase with increase in moisture content from 2.87 to 19.98% w.b. The porosity of kernel was found to slightly increase with increase in moisture content from 2.77 to 19.89% w.b. He added that, the projected area of hazel nut increased by about 17.99%, with increase in moisture content of nut. Furthermore, the projected area of kernel increased by about 16.4%, with increase in moisture content.

Aydin (2003) reported that the true density of almond nut at different moisture levels varied from 1015 to 1115 kg/m³ at the moisture range from 2.77 to 24.97% wb. The effect of moisture content on true density of almond nut showed an increase with moisture content. Effect of moisture content on true density of kernel showed an increase with moisture content from 900 to 995 kg/m³ at the moisture range from 2.77 to 24.97% wb.

Ozdemir and Akinci (2004) reported that the static coefficient of friction for hazelnuts and kernels was determined on the plywood.
These coefficient values varied from 0.212 to 0.296 and 0.298 to 0.376, respectively. On the galvanized iron sheet, the static coefficient of friction for hazelnuts and kernels were found to be statistically insignificant, varying from 0.221 to 0.242 and from 0.271 to 0.297, respectively.

Yildiz (2005) reported that the variation of the coefficient of static friction with moisture content in mash bean seeds, for iron sheet and galvanized iron sheets. That the coefficient of static friction values on an iron sheet and one galvanized iron sheet increased with the increase of moisture content. The coefficient of static friction increased from 0.270 to 0.322 and from 0.302 to 0.367 for galvanized iron sheet and iron sheet respectively. He added that the projected areas values of mash bean seeds at moisture contents of 6.66 and 18.59 % varied from 0.140 to 0.213 cm$^2$.

MATERIALS AND METHODS

To achieve the large of this experimental work, selected variety main namely (Almara). The apricot pits samples were cleaned to removed all foreign materials and divided into three samples randomly order to obtain three different levels of moisture content. The apricot pits desired moisture content levels were achieved by incubated in water for 1 and 2 hours before the experiment (Inan 2001).

A- Materials:

The study was carried out using local variety namely (Alamar)

B- Measuring instrumentation:

1- Digital vernire caliper:

It was used for measuring the dimensions of apricot pits and apricot kernel.

2- Electrical balance: accuracy 0.01 g.

3- Electrical oven with forced hot air circulation.

C- Experimental procedures:
The main experiments were conducted to determine and calculated the physical and mechanical properties of apricot variety under study. Apricot pit and apricot kernel dimensions (length, width and thickness), mass, volume, geometric diameter, bulk and real densities, percent of sphericity, projected area, angle of repose and coefficient of friction were measured and estimated. All the experiments were replicated three times.

1- Physical properties of apricot pits and apricot kernels:

Pits and kernel dimensions (L, W and T), mass, volume, geometric diameter, bulk and real densities, percent of sphericity and projected area. Standard deviation, coefficient of variation, maximum, minimum, and arithmetic mean. The calculated equations according to EL Raie et al. (1996) studies that, the size of apricot pits and kernels in terms of length (L), width (W) and thickness (T). The size was used to calculate geometric diameter (Dg), percent of sphericity (S) of the individual pits and kernels. The following equations were used to calculate the values of the above mentioned properties:

\[
V = \frac{\pi}{6} (LWT) \\
D_g = (LWT)^{1/3} \\
S = (LWT)^{1/3}/L
\]

- Volume of individual pit and kernel:

The pit and kernel volume were determined using the liquid displacement method. Toluene (C_7 H_8) was used in place of water because it is absorbed by pit to a lesser extent. Also, its surface tension is low, so that it fills even shallow drips in a pit and its dissolution power is low (Mohsenin 1980).

- Real density of pit and kernel:

Real density or individual pit and kernel density (\(\rho_r\)) : random samples of pits and kernels were used to calculate the pit and kernel density as follows:

\[
\rho_r = \frac{W}{V} \text{ g/cm}^3
\]
Where:

\[ \rho_r = \text{the real density of the individual grain, g/cm}^3; \]
\[ W = \text{Weight of the individual grain, g}; \]
\[ V = \text{Volume of the individual grain, cm}^3. \]

- Bulk density of pit and kernel:
It was calculated for pits and kernels by dividing the mass of a quantity of pits and kernels on its volume, which was measured by using a constant volume cylinder:
\[ \rho_b = \frac{W_b}{V_b} \]
Where:
\[ \rho_b = \text{the bulk density of pits and kernels, g/cm}^3 \]
\[ W_b = \text{mass of the same quantity of pits and kernel, g} \]
\[ V_b = \text{volume of the same quantity of pits and kernel, cm}^3 \]

- The moisture content for apricot (pits and kernels) is evaluated according to the ASAE standards (1994) i.e., oven dried at 103°C for 24 hours.

2- Mechanical properties of pits and kernel:
- Repose angle \( \theta^o \): it is the angle between the horizontal base and inclined side of the formed cone due to free fall of pit or kernel sample. The horizontal base of the cone (D) and its height (h) were measured by a ruler and repose angle can be calculated as follows:
\[ \tan \theta^o = \frac{h}{0.5 D} \]
- Friction angle \( \phi^o \): it was measured between different surfaces and apricot pits and kernels according to Mohsenin (1970).
- The hardness device:
The rupture strength values of stone were measured by forces applied through three axes (length, width and thickness). To determine the rupture strength of grains, hardness material test device has three main components (X, Y, and Z) which are stable upend motion bottom of platform.
RESULTS AND DISCUSSIONS

Linear dimension:

The variations of length, width, thickness and geometric diameter the apricot pits and apricot pit moisture content are shown in fig. (2).

Dimensions along the three principle axis were from 8 % up to 15 % moisture content, there is no appreciable dimensional change, thereafter all dimensions increase with apricot pit moisture content from 15 % up to 19 %. The pits probably retain some air voids as they absorb water which replaced with water from 8 % up to 15 % moisture content there by making the pits display no dimensional change.

The total average was largest along the pit length and least along its width and thickness.

While, the geometric diameter slightly increased with apricot pit moisture content increased.
The dimensions of apricot kernel the length was ranged from 13.5 to 17.5 mm with mean value of 15.29 mm, the width was ranged from 8.25 to 12.75 mm with a mean value of 10.47 mm, the thickness was ranged from 4.5 to 6.3 mm with a mean value of 5.27 mm and the geometric diameter was ranged from 7.80 to 10.60 mm with a mean value of 9.32 mm at moisture content 24%.

**Bulk density, True density and Porosity:**

Bulk density, true density and porosity were measured for apricot pits. The results as shown in fig. (3) and (4) were found to be dependent on moisture content. The following linear regression equations described the relationship between each of bulk density ($\rho_{bp}$), true density ($\rho_{bt}$) and porosity ($\varepsilon_p$) and moisture content in percent (d.b).

$$\rho_{bp} = 598.67 - 31.5 \text{ Mc} \quad \cdots \cdots \cdots \cdots \cdots \quad R^2 = 0.9763$$

$$\rho_{bt} = 1233.3 - 70 \text{ Mc} \quad \cdots \cdots \cdots \cdots \cdots \quad R^2 = 0.9932$$

$$\varepsilon_p = 61.667 - 4.5 \text{ Mc} \quad \cdots \cdots \cdots \cdots \cdots \quad R^2 = 0.9067$$

These equations showed that each of bulk density, true density and porosity show in Fig. (5) for apricot pits. The bulk and true densities and porosity were evaluated as function of moisture content in the ranged from 8 to 19%. The bulk and true densities and porosity increased form (507 to 570 kg/m$^3$), (1020 to 1160 kg/m$^3$) and (49 to 58 %) respectively.
While, bulk and true densities and porosity were measured for apricot kernel at moisture content of 24 %. The bulk density were ranged from 445 to 535 kg/m³ with mean value 497 kg/m³, the true density were ranged from 795 to 895 kg/m³ with mean value 840 kg/m³ and the porosity ranged from 39.5 to 44.5 % with mean value 42 %.

**Mass:**
The dependence of grain mass of apricot pits on moisture content were found to be between 1.75 to 1.84 g. The apricot kernel mass were ranged from 0.40 to 0.63 g with a mean value 0.48 g.

**Volume:**
The dependence of grain volume of apricot pits on moisture content were found to be between 0.16 to 0.17 cm³. The apricot kernel volume were ranged from 0.50 to 0.72 cm³ with a mean value 0.62 cm³.
Rupture force:
The force required to initiate pit rupture at different moisture content and compression axes is shown in fig.(6).

It can be observed that the force required to initiate pit rupture decreased along the X, Y, Z-axes as moisture content increased from 8 to 19\% wb.

Apricot pit compressed along the X-axis required 1397.9, 773.0 and 581.4 N at moisture content of 8, 15 and 19\% respectively.

The relationship between moisture content and rupture force of apricot pit compressed along the X, Y and Z –axes can expressed equation as follows:

\[ F_x = 100.93 + 403.25 \text{Mc} \quad \ldots \quad R^2 = 0.9142 \]

For compression along the Y- axis the rupture force decreased from 1177.2 to 341.97 N with increase in moisture content from 8 to 19\%.

The relationship between moisture content and rupture force of apricot pit compressed along the Y –axis can expressed equation as follows:

\[ F_y = 417.65 \text{Mc} – 172.37 \quad \ldots \quad R^2 = 0.8617 \]

The relationship between moisture content and rupture force of apricot pit compressed along the Z –axis can expressed equation as follows:

\[ F_z = 223.25 \text{Mc} – 70.3 \quad \ldots \quad R^2 = 0.9369 \]

Angle of repose:
Dynamic angle of repose for apricot pits as shown in fig (7) showed linear relationship the apricot pit moisture content. The following linear regression equation described the relationship between the dynamic repose angle (θ) in degree and moisture content percent.
\[ \Theta = 43.973 - 3.945 \text{Mc} \quad \text{.....................} \quad R^2 = 0.9605 \]

The angle of repose was evaluated as a function of moisture content range of 8 to 19%. The average angle of repose increased from 32.60 to 40.49°.
Static friction coefficient:

The static coefficient of friction for apricot pits of the investigated on the selected materials surface including Carboard, Rubber, Plywood, Iron sheet and Glass as shown in fig (8) appeared to be linearly dependent on the moisture content.

The relationship between moisture content and static coefficient of friction cardboard ($\mu_c$), rubber ($\mu_r$), plywood ($\mu_p$), iron sheet ($\mu_I$) and glass ($\mu_g$) can be represented by the following linear regression equations:

\[
\begin{align*}
\mu_c &= 0.79 - 0.10 \text{Mc} \quad \text{R}^2 = 0.9643 \\
\mu_r &= 0.8933 - 0.075 \text{Mc} \quad \text{R}^2 = 0.848 \\
\mu_p &= 0.6133 - 0.06 \text{Mc} \quad \text{R}^2 = 0.9908 \\
\mu_I &= 0.5767 - 0.055 \text{Mc} \quad \text{R}^2 = 0.8811 \\
\mu_g &= 0.2833 - 0.02 \text{Mc} \quad \text{R}^2 = 0.9231
\end{align*}
\]

The equations showed that the static coefficient of friction for apricot pits of the studied variety increased with increasing the moisture content at the studied range on each of the five material surfaces. At all moisture content levels for apricot pits, the highest values of static coefficient of friction were on rubber followed by cardboard, iron sheet and lowest on glass.
CONCLUSION

- The dimensional properties and mass of apricot pit increased depending on moisture content as following length, width, thickness and geometric diameter increased from (20.81 to 22.53 mm), (17.44 to 18.02 mm), (11.38 to 11.66 mm) and (15.9 to 16.1 mm), respectively.

- The mass, bulk, true densities and volume increased with moisture content as following, from 1.75 to 1.84 g, from 507 to 570 kg/m$^3$, 1020 to 1160 kg/m$^3$ and from 0.16 to 0.17 cm$^3$ respectively.

- The rupture force on both axes decreased with moisture content in apricot pit as following:

- The relationships between moisture content and rupture force of apricot pit compressed along the X, Y and Z – axes can expressed equations as follows:

  \[
  F_x = 100.93 + 403.25 \text{Mc} \quad R^2 = 0.9142 \\
  F_y = 417.65 \text{Mc} - 172.37 \quad R^2 = 0.8617 \\
  F_z = 223.25 \text{Mc} - 70.3 \quad R^2 = 0.9369
  \]

- The porosity and angle of repose increased with moisture content in apricot pit as following from 49 to 58 %, and from 32.6 to 40.49º respectively.

- The coefficient of static friction increased from (0.41 to 0.77), (0.65 to 0.80), (0.43 to 0.55), (0.40 to 0.51) and (0.22 to 0.26) for cardboard, rubber, wood, iron and glass respectively.

  The apricot kernels, dimension properties (length, width and thickness) were 15.29, 10.41 and 5.27 mm respectively, the mass was 0.48 g, the volume was 0.62 cm$^3$, the bulk and true densities were 497 and 840 kg/m$^3$ respectively, the geometric diameter was 9.32 mm, the sphercity was 59 % and the porosity was 42%.

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الم הפרי
بعض الخواص الطبيعية لنوى المشمش

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تعتبر عملية تكسير نوى المشمش واحدة من أهم العمليات التي تجري على نوى المشمش حيث يتفاوت عن استهلاك المشمش في مصر ما يقرب من 30 ألف طن نوى سنويا في عمليات التصنيع فقط، والتي تعتبر من أهم عمليات إعادة تدوير مخلفات التصنيع الغذائي حيث يمكن الاستفادة من نوى المشمش في الأتي:

1- تحضير الكربون النشط عالي الكفاءة من نوى المشمش حيث يستطيع أن يزيل الاملات الناتجة عن العمليات الصناعية والغذائية ومياه الشرب و يعد هذا الكربون النشط من أشهر مواد التنقية في العمليات الصناعية والغذائية المختلفة منذ عدده عقود. و زاد استخدامه هذا أخيرا وظهرت أهميته بسبب زيادة التلوث في الماء، كما أنه يعد من أشهر مواد معالجة المتبقات الضليلة لكافحته العالية لإزالة عشرات المركبات والملوثات، وذلك يصل الاستهلاك العالمي منه الآن إلى 380 ألف طن و يتراوح ثم الطن حوالي 400 ألف جنيه مصري، وتستورد مصر حاليا كل احتياجاتها من الداخل للاستعمالات الصناعية وتنقية مياه الشرب.

2- عند زراعة المشمش لابد من كسر طبقة الأندوكارب الصلبة مع الحرص على ألا يحدث ضرر للجذور (البذرة) حيث تزال النوى الصلبة بكسارها باستعمال شاكيش أو الهيدوية.

3- استخراج زيت اللوز المر وهو زيت عطري يستخرج من البدور المهروسة والمصورة جذريا و يستعمل زيت اللوز المر في إكباب النكهة للمشروبات الغير كحولية والجيلاتي والبوننج والفواكه المسكرة.

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مهندس زراعي.
4- تؤكل بعد إزالة الطعم المر النتج عن جليكوزيد الامجدالين أو بإضافة كمية قليلة للتوابل كمشيئيت أو تدخل في صناعة الهوى.
5- يدخل في تركيبات بعض الأدوية.

تهدف هذه الدراسة إلى توفير قائمة معلومات للخصائص الطبيعية لنوى وليب المشمش وعلاقتها بالمحتوى الرطبي عند ثلاثة مستويات رطوبة حوالي 8% ، 15% ، 19%. أما الخصائص الطبيعية المدروسة فكانت الخصائص البدنية والتنموية وسمك النوى و الكثافة الظاهرة والكثافة الحقيقية للنوى كجم/م3 ووزن النوى و قوة الكسر و زاوية المكوث و معامل الانهكاك الاستناثي للنوى على خمسة أسطح مختلفة و هي الكرتون و المطاط و الخشب والزجاج.

ويمكن تلخيص متوسط النتائج المتحصل عليها للخصائص الطبيعية والميكاتيكية للقشرة الخارجية لنوى المشمش كالآتي الطول 20.81 مم والعرض 17.64 مم والسماك 11.83 مم والكتلة 1.75 جم والكروية 0.75% والكثافة الظاهرة 0.57 كجم/متر3 وكتافة حقيقية 1.02 كجم/متر3 والحجم 0.16 سم3 والمسامية 49% و متوسط قطر الهندسي 15.9 مم، ومساحة السطح 29.2 مم2 و زاوية التكتم 32.60 ودبيل الشكل 1.45 عند محتوى رطبي 8% على الترتيب.

تم دراسة قوة الكسر الواقعة على القشرة الخارجية لنوى المشمش على الثلاثة اتجاهات والنتائج كالآتي في اتجاه الطول 1397.9 نيوتن وفي اتجاه العرض 1177.2 نيوتن واتجاه السماك 632.2 نيوتن عند محتوى رطبي 8% للنوى على الترتيب.

العلاقة بين رطوبة النوى وقوة الكسر على الثلاثة محاور لنوى المشمش كما هو مبين بالمعادلات الآتية:

$F_x = 100.93 + 403.25 \text{Mc}$  \hspace{1cm} $R^2 = 0.9142$

$F_y = 417.65 \text{Mc} - 172.37$  \hspace{1cm} $R^2 = 0.8617$

$F_z = 223.25 \text{Mc} - 70.3$  \hspace{1cm} $R^2 = 0.9369$

تم دراسة أيضا للخواص الطبيعية للب الداخلي لنوى المشمش ومتوسط النتائج المتحصل عليها كالآتي الطول 15.29 مم والعرض 10.44 مم والسماك 5.27 مم والكتلة 0.84 جم والمسامية 42.0% والكثافة الظاهرة 497 كجم/متر3 وكتافة حقيقية 84.0 كجم/متر3 والحجم 0.22 سم3 والكروية 0.59% و متوسط قطر الهندسة 9.32 مم عند مستوى رطوبة 24%.