J. Agric. Sci. Mansoura Univ., 32 (6): 4565 - 4574, 2007

MECHANICAL PROPERTIES FOR SOME VARIETIES OF OLIVE FRUITS

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ABSTRACT

A study was carried out to determine some mechanical properties for fruits and pits of different olive varieties. The studied varieties included Coratina, Kronaki and Arab queen as oil producing varieties and Picual, Manzanillo and Watiken as duel purpose varieties. The investigated properties for olive fruits included coefficient of friction, repose angel and rolling angle. While hardness, shear force and shear stress were determined for pits.

The results show that, the oil producing varieties showed lower friction coefficient in comparison with the duel purpose varieties. Also, the rubber surface recorded highest coefficient of friction followed by the galvanized iron and stainless steal surfaces. On the same time, the fruit repose angle not only affected by the surface roughness of fruits but also the shape and size of fruits as the fruit size increased, the repose angle increased. However, varieties of small size recorded lower rolling angle for all studied surfaces in comparison with varieties of large size. The results also show that, the pit crushing force, shear force, and shear stress were higher for the duel purpose varieties in comparison with the oil producing varieties.

INTRODUCTION

Olive crop is considered one of the main crops in Egypt especially in the new reclaimed area. The cultivated area is increasing about 1000 Feddans per year, thus, the olive tree can grow well in a very hard climate and can resist shortage in water supply (Ghonimy, 1997).

The preceding agricultural statistically illustrated that the cultivated area of olive in Egypt increased from 82.685 in 1996 to 134.608 feddans in 1999 with approximately 62.8% increase. Also the total production of olive fruits increased from 208.133 in 1996 to 288.027 tons in 1999 with 38.4% increase (Agricultural Statistics, 1999).

The total productivity of oil in Egypt represents 15 – 25% of the total oil requirements, while 75 – 83% is exported from different countries. So it is necessary to find other resources different than the main resources such as cotton, maze and sunflower seeds. The olive oil is almost unique among vegetable oils and it has capability for consuming without any refining treatment. Therefore, number of olive varieties have been imported as foreign varieties and grown side by side with the local varieties in different locations in Egypt (Owies, 2003).

The mechanical extraction of oil from olives is made possible by the sight steps aimed at freeing the tiny drops of oil contained in each cell of the olive pulp. This process is greatly affected by the physical and mechanical properties of different oil varieties (Matouk *et. al.,* 2005).

Mechanical properties such as compressive strength, impact, shear resistance, repose angle and coefficient of friction are important and in some cases necessary for studying size reduction. From energy stand-point, this information can also be used to determine the best method to breakup or grind agricultural products.

For this reasons, it is essential to understand the physical and mechanical laws governing the response of agricultural biological materials so that the machines, processes, and handling operations can be designed for the maximum efficiency and the highest quality of the end product. (Sitel 1986, Pearson *et. al.,* 1994 and El-sahrigi, 1997).

However, variations in both physical and mechanical properties were found not only between different crops but also between varieties of each crop. (Matouk *et. al.,* 2000).

The present study aims to determine some mechanical properties for different varieties of oil producing and duel purpose olive fruits. The selected varieties represent the local and the exported olive cultivars in the main producing areas of Siwa, Arish, and Sahrawy road.

MATERIALS AND METHODS

The selected olive varieties in the present study were classified as:

a- Oil producing varieties (Coratina, Kronaki and Arab queen).

b- Duel purpose varieties (Picual, Manzanillo and Watiken).

The selected varieties were collected at the full ripening stage from different cultivated areas of Arish, Siwa and Sahrawy road. The collected samples were located at perforated plastic boxes with full capacity of 20 kg/box. The boxes were labeled with all required data of each variety and stored at a commercial refrigeration unit adjusted at 4°C ± 1. The average moisture content of the stored varieties was ranged from 58 to 65% (w.b.).

Experimental Measurement and Test procedure:

The experimental measurements were conducted for the fruits and their pits. The investigated mechanical properties for the fruits of different varieties included coefficient of friction at various surfaces, repose angle and rolling angle. While, hardness, shear force and shear stress were determined, for their pits. The collected data were statistically analyzed to determine the mechanical characteristics of each variety and the variations between varieties of different categories. On the same time, empirical equations were deduced to describe the obtained data.

Fruits coefficient of friction:

The angle of friction for different studied olive varieties was measured at three different surfaces of (galvanized iron, stainless steel and rubber) using the digital friction angle meter shown in Fig. (1). The working theory of this meter depends upon the adjustment of the base screw switch to be suitable for the weighed fruits. Fruit samples of each variety were tied together by sticking them on a sticky paper. The paper and the stacked fruits were placed upside down over the tested surface which allowed tilting up around its side pivot. The angle of friction (Φ) was displayed when the fruits reached the spout and the tray was stopped. The coefficient of friction was estimated according to the following equation:

$$\mathbf{F} = \mathbf{F}/\mathbf{F_n} = \mathbf{G}\sin\phi / \cos\phi = \tan\phi \quad \text{........... (1)}$$

Where:

F = Coefficient of friction
F/F_n = the ratio between the frictional force (F) and the normal force (F_n).
Ø = the friction angle.

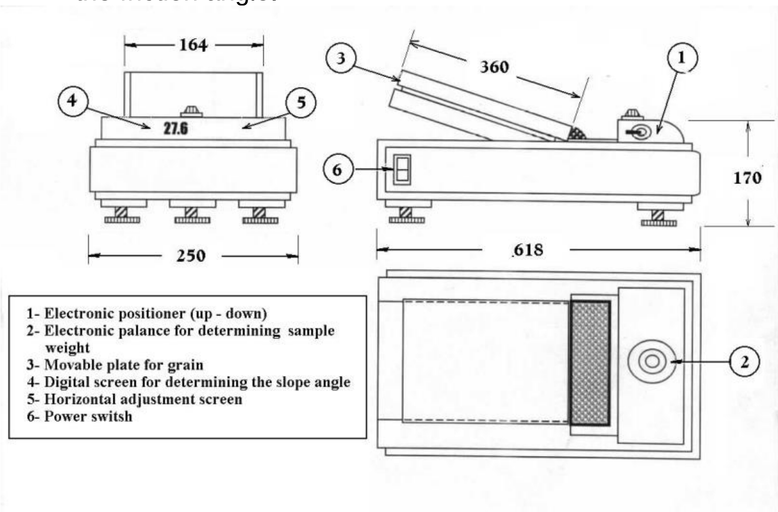


Fig. (1): Friction angle meter.

Fruits repose angle:

The measuring instrument of (Buyanov and Voronyuk, 1985) was fabricated and used to measure the constructive angle of repose for different studied olive varieties. The instrument consists of a stainless steel box with dimensions of 100 × 30 × 20 cm. It has one transparent side with dimensions of 100 × 30 cm and a door with dimensions of 30 × 20 cm. A wooden parallelogram with a base fixed in the protector was used for measuring the angle of repose.

A knowing weight of olive fruits (around 10 – 20 kg) were poured under gravity from a suitable height into the apparatus. The rectangular box is kept in the vertical position and the free surface of the fruits is leveled. The box is gradually tilted into the horizontal position. The free surface of the olive fruits then makes an acute angle (α) with respect to the horizontal. The angle between the free surface of the fruits and the horizontal plan represents the repose angle of fruits as shown in Fig. (2). The recorded angle was the average of five replicates.

Fruits rolling angle:

The fruit rolling angle was measured using the angle of friction meter (Fig. 1). The meter tray was fixed at the horizontal position and 10 fruits were placed over the tested surface (metal, stainless steel, rubber).

The meter tray starts to gradually tilt up around its side pivot and the meter reading recorded immediately as the fruit start to roll. The recorded angle represents the angle of repose and average of five replicate was considered for each tested surface.

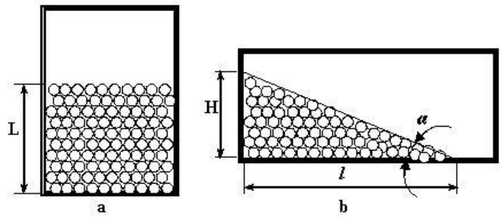


Fig. (2): Angel of repose apparatus.

Pit hardness:

The digital hardness meter model FGN-50 with accuracy of 0.1 Newton was used for measuring the pit hardness. A single fruit was pressed by the conical end of the apparatus, and the digital reading was increased with the increasing of the pressure on the pit until the fruit has been cracked. At this point, the recorded reading (peak) is the pit hardness.

Pit shear force:

Shear force for the investigated olive varieties were determined using the hardness meter with the straight sharp edge instead of the conical end. The olive pit was fixed on the apparatus plate whereas; the longitudinal axis was perpendicular to the sharp edge. The passing wheel was turned until the sharp edge cut the olive pit. The recorded reading represents the shear force at this cross section area.

Pit shear stress:

Shear stress was calculated by dividing the shear force by the cross section area of the same olive pit as mentioned by (Owies, 2003).

RESULTS AND DISCUSSION

Fruits coefficient of friction:

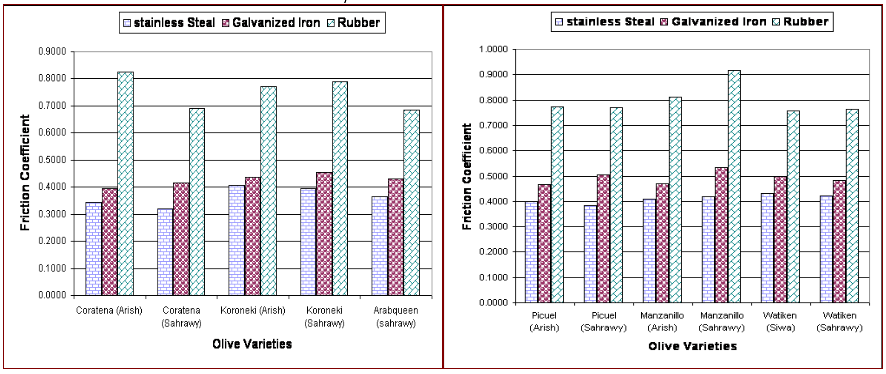
Coefficient of friction for the investigated oil producing and duel purpose varieties are presented in Fig. (3). The figure shows that, both of olive fruits and the tested surfaces affected the values of friction coefficient. The highest coefficients of friction for all studied varieties were obtained on rubber surface followed by galvanized iron and stainless steel surfaces.

Meanwhile a notable variation was observed for all studied varieties at each studied surface. For oil producing varieties, Fig. (3) shows that, at stainless steel surface, variety Kronaki Arish recorded the highest coefficient of friction (0.405) while variety Kronaki Sahrawy recorded the lowest value of (0.319).

However, at the galvanized iron surface, variety Coratina Arish recorded the highest value of (0.396) and variety Kronaki Sahrawy recorded the lowest value of (0.456). Meanwhile, at rubber surface, variety Coratina Arish recorded the highest coefficient of friction (0.825) and variety Arab queen recorded the lowest value of (0.685).

On the other hands, for duel purpose varieties, Fig.(3) shows that, at stainless steel surface, variety Watiken Sahrawy recorded the highest coefficient of friction (0.432) while variety Picual Sahrawy recorded the lowest value of (0.384). While, at the galvanized iron surface, the highest recorded value for friction coefficient was (0.505) for variety Picual Sahrawy while the lowest value of (0.468) was recorded for variety Picual Arish. On the same time, at the rubber surface variety Manzanillo Sahrawy recorded the highest coefficient of friction (0.918) while variety Watiken Siwa recorded the lowest value of (0.753).

The above mentioned results revealed that, oil producing varieties showed lower friction coefficient in comparison with duel purpose varieties and the variations in friction coefficients for all studied varieties were due to the differences in contact area, mass and size of fruits.



Oil varieties **Duel varieties**

Fig. (3): Coefficient of friction for the investigated oil producing and duel purpose olive varieties

Fruit repose angle:

Fig. (4) illustrates the average values of repose angle for different investigated oil producing and duel purpose varieties .

For oil producing varieties, Fig.(4) shows that, varieties Coratina Arish and Coratina Sahrawy recorded the highest values of repose angle (35.33) and (35.00) followed by varieties Kronaki Sahrawy and Kronaki Arish which recorded a values of 33.17 and 32.83 respectively. On the same time, variety Arab queen recorded the lowest value of (31.33).

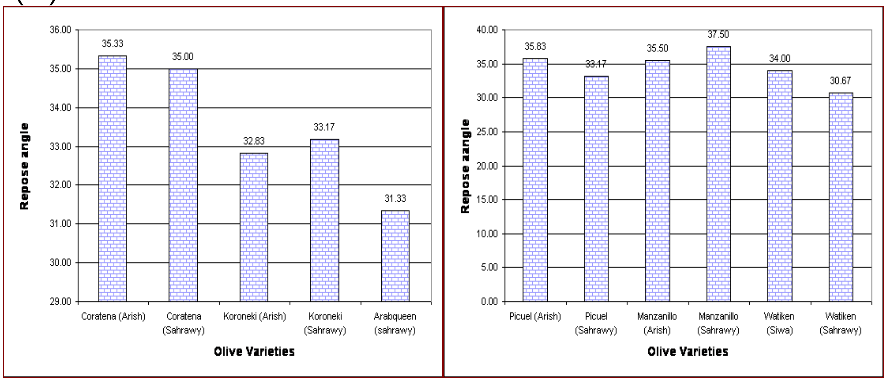
Meanwhile, for duel purpose varieties, the figure shows that, variety Manzanillo Sahrawy recorded the highest repose angle of (73.5) followed by varieties Picual Arish, Manzanillo Arish, Watiken Siwa, Picual Sahrawy and Watiken Sahrawy which recorded a values of (35.83), (35.50), (34.00), (33.17) and (30.76) respectively.

The above mentioned results revealed that, not only the surface roughness of fruits directly affecting the repose angle, but also shape and size of fruit play an important role. As the fruit size increased the repose angle increased.

Fruit rolling angle:

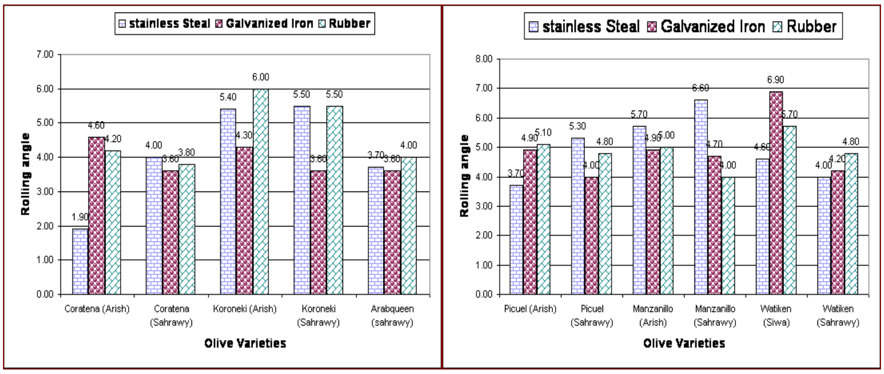
Rolling angle of different studied olive varieties were determined and presented in Fig.(5). As shown in the figure, rubber surface showed the highest values of rolling angle followed by the galvanized and stainless steel surfaces respectively.

For the oil producing varieties, Fig. (5) shows that, at stainless steel surface variety Kronaki Sahrawy recorded the highest rolling angle of (5.5°), while variety Coratina Arish recorded the lowest value of (1.9°). While, at the galvanized iron surface, a similar value of (3.6°) was recorded for varieties Coratina Sahrawy , Kronaki Sahrawy and Arab queen. At rubber surface, variety Kronaki Arish recorded the highest rolling angle of (6.0°) and variety Coratina Sahrawy recorded the lowest value of (3.8°). For the duel purpose varieties, Fig. (5) also, shows that, at stainless steel surface variety Manzanillo Sahrawy recorded the highest rolling angle of (6.6°) while variety Picual Arish recorded the lowest value of (3.7°). At the galvanized iron surface, variety Watiken Siwa recorded the highest rolling angle of (6.9°), while, variety Picual Sahrawy recorded the lowest angle of (4°). On the same time, at the rubber surface, variety Watiken Siwa recorded the highest rolling angle of (5.7°) while, variety Manzanillo Sahrawy recorded the lowest angle of (4°).



Oil varieties **Duel varieties**

Fig. (4): Repose angles for the investigated oil producing and duel purpose olive varieties.



Oil varieties **Duel varieties**

Fig. (5): Rolling angles for the investigated oil producing and duel purpose olive varieties

In general, varieties of small volumes recorded lower values of rolling angle at all studied surfaces in comparison with the varieties of large volumes.

Pit crushing force:

Fig. (6) shows the normal distribution curves and mean values of pit crushing force for oil producing and duel purpose varieties. For oil producing varieties, Arab queen and Coratina Sahrawy recorded the highest crushing forces of (447.236 N) and (413.579 N), while varieties Kronaki Arish and Kronaki Sahrawy recorded the lowest values of (282.331 N) and (279.978 N.) respectively. For duel purpose varieties, Picual and Manzanillo Sahrawy recorded the highest values of crushing force (569.356 N) and (563.543 N) respectively, While, variety Watiken Siwa recorded the lowest value of (474.472 N).

The frequency distribution curves presented in Fig. (6) also show that, oil producing varieties Coratina Sahrawy and Arab queen recorded the highest dispersions in crushing force. The statistical analysis also showed that, the coefficient of variance (C.V.) for different oil producing varieties Coratina Sahrawy, Arab queen, Coratina Arish, Kronaki Arish and Kronaki Sahrawy were 21.672, 20.72, 17.75, 14.16 and 13.57 % respectively.

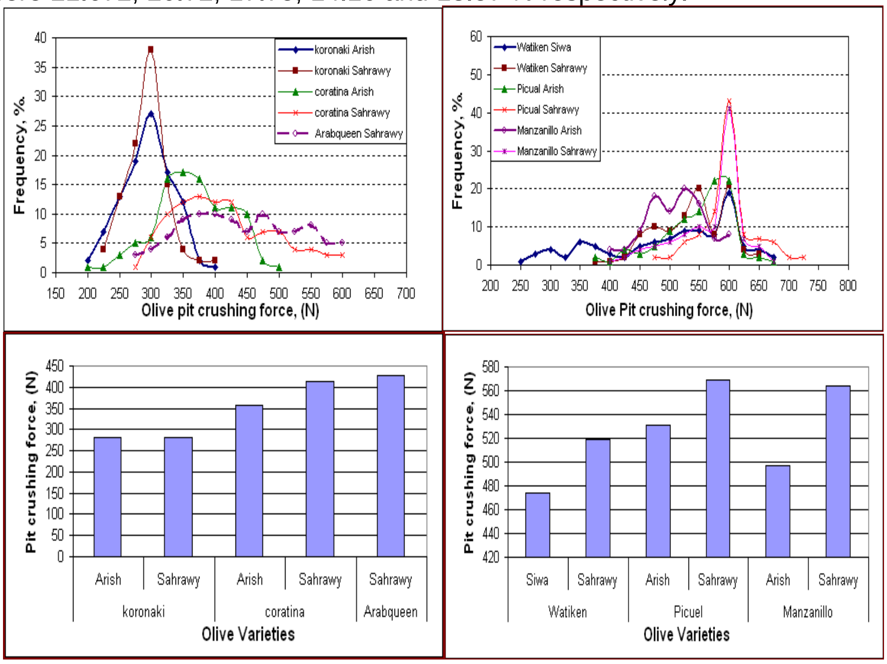


Fig. (6): Normal distribution curves and mean values of Pit crushing force for the investigated oil producing and duel purpose olive varieties

For the duel purpose varieties, the frequency distribution curves show that, variety Watiken Siwa recorded the highest (C.V.) value of (22.482 %) followed by varieties Watiken Sahrawy, Picual Arish, Manzanillo Arish, Manzanillo Sahrawy and Picual Sahrawy which recorded values of 11.404, 10.85, 10.22, 8.29 and 7.73 % respectively.

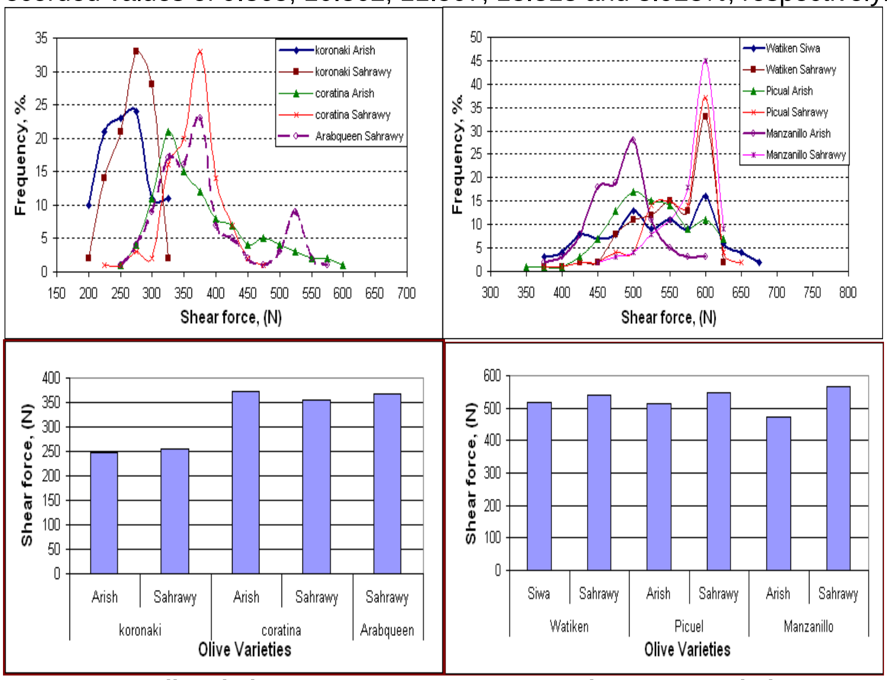
Pit shear force:

Pit shear force for all the investigated oil producing varieties were measured and presented in Fig.(7), it can be seen that varieties Coratina Arish and Arab queen recorded the highest shear forces of (371.682 N) and

(367.799 N) respectively, while, varieties Kronaki Sahrawy and Kronaki Arish recorded the lowest values of (256.225 N) and (247.402 N) respectively. The frequency distribution curves for oil producing varieties also show that, varieties Coratina Arish and Arab queen recorded the highest dispersions and the highest (C.V.) values of (22.282 and 20.18 %) respectively. While, varieties Kronaki Arish, Coratina Sahrawy and Kronaki Sahrawy recorded a close values of (14.74, 12.185 and 11.03 %), respectively.

For duel purpose varieties, Fig. (7) also shows that, variety Watiken Siwa recorded the highest pit shear force of (567.927 N) followed by varieties Watiken Sahrawy, Picual Sahrawy, Manzanillo Sahrawy, Picual Arish and Manzanillo Arish which recorded values of (547.441, 540.289, 518.650, 514.446 and 471.888 N), respectively.

On the same time, the frequency distribution curves show that, variety Watiken Siwa recorded the highest (C.V.) of 16.384% followed by varieties Manzanillo Arish, Picual Sahrawy, Watiken Sahrawy and Picual Arish which recorded values of 9.865, 10.862, 11.567, 13.818 and 8.923%, respectively.



Oil varieties **Duel purpose varieties**

Fig. (7): Normal distribution curves and means values for Pit shear force of oil producing and duel purpose olive varieties

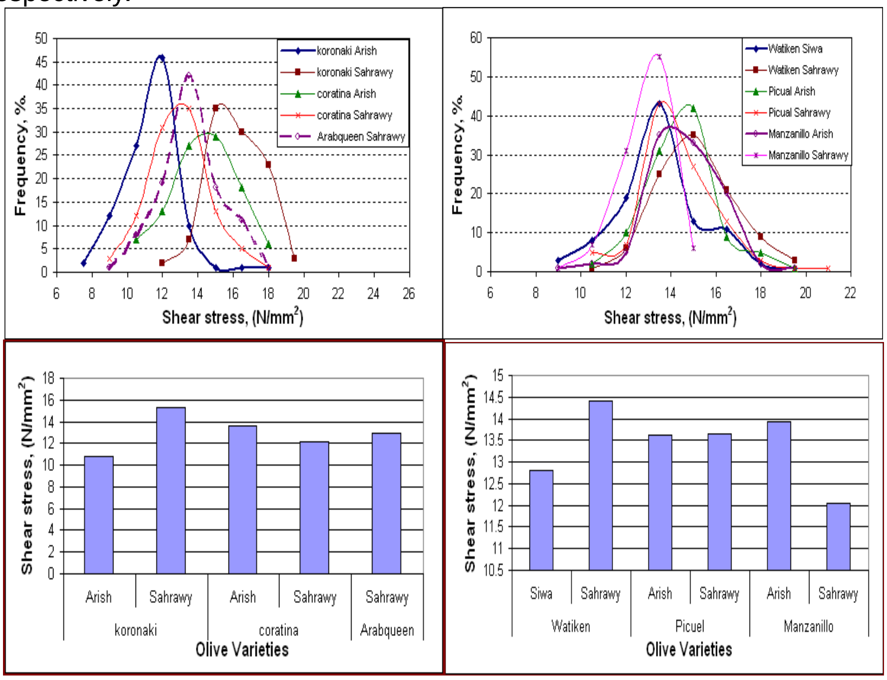
Pit shear stress:

Pit shear stress for all studied varieties was calculated by dividing the shear force by the pit cross section area. The obtained results for oil producing and duel purpose varieties were plotted and presented in Fig. (8). For oil producing varieties, the data showed that variety Kronaki Sahrawy recorded the highest pit shear stress of (15.252 N/mm^2) followed by varieties Coratina Arish, Arab queen Sahrawy, Coratina Arish, Kronaki Arish and

Kronaki Sahrawy which recorded a pit shear stresses of (13.633, 12.393, 12.156 and 10.769 N/mm²) respectively.

However, for duel purpose varieties, variety Watiken Sahrawy recorded the highest pit shear stress of 14.397 N/mm² followed by varieties Picual Arish, Picual Sahrawy, Manzanillo Arish, Watiken Siwa and Manzanillo Sahrawy which recorded a pit shear stresses of 13.63, 13.65, 13.49, 12.80 and 12.06 N/mm², respectively.

The frequency distribution curves also cleared that, variety Watiken Siwa recorded the highest (C.V.) of (15.941 %) followed by varieties Manzanillo Arish, Watiken Sahrawy, Picual Sahrawy, Picual Arish, and Manzanillo Arish which recorded values of (14.243, 13.346, 12.570, 11.371 and 8.314 %) respectively.



Oil varieties **Duel varieties**

Fig. (8): Normal distribution curves and mean values of Pit shear stress for the investigated oil producing and duel purpose olive varieties

CONCLUSION

1- The oil producing varieties showed lower values of friction coefficient in comparison with the duel purpose varieties.
2- Not only the surface roughness of fruits directly affecting the repose and rolling angles, but also shape and size of fruits play an important role. As the fruit size increased, both the repose and rolling angle increased.
3- The pit crushing force, shear force and shear stress were higher for the duel purpose varieties in comparison with the oil producing varieties.

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الخصائص الميكانيكية لبعض أصناف الزيتون

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نظرا لأهمية محصول الزيتون كأحد أهم المحاصيل الزيتيه في مناطق الإستصلاح الجديدة فقد تم إستنباط العديد من الأصناف المحلية والمستوردة عالية الإنتاجية وحيث أن الخصائص الطبيعية والميكانيكية لتلك الأصناف تختلف بإختلاف الصنف، المنطقة المنزرعة وكذلك غرض الإنتاج (أصناف زيت، أصناف ثنائية الغرض) فقد أجريت تلك الدراسة لتعيين أهم الخصائص الميكانيكية لبعض أصناف الزيتون المنتجة للزيت (كرواتينا، كروناكي، أرب كوين) والأصناف ثنائية الغرض (بيكوال، منزانيللو، وطيقن) والمنزرعة في مناطق العريش، سيوه، الطريق الصحراوي.

وقد تم قياس كل من معامل الإحتكاك على الأسطح المختلفة، زاوية المكوث، زاوية التدحرج للثمار بينما تم قياس كل من درجة الصلابة، قوى القص، إجهاد القص للبذور.

أظهرت النتائج المتحصل عليها إنخفاض معامل الإحتكاك للثمار أصناف الزيت بالمقارنة بالأصناف ثنائية الغرض وذلك على جميع الأسطح موضع الدراسة (الصاج المجلفن – الستانلس – المطاط) كما أعطى السطح المطاط أعلى قيم لمعامل الإحتكاك بالمقارنة بباقي الأسطح.

من ناحية أخرى زادت قيم كل من زاوية المكوث والتدحرج بزيادة أبعاد وحجم الثمار وكذلك درجة خشونة سطح الثمرة لجميع الأصناف موضع الدراسة. كما كانت كل من قوى التحطم، قوة القص وإجهاد القص أعلى للأصناف ثنائية الغرض بالمقارنة بأصناف الزيت.