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Mechanical Behavior of Apricot and Cherry Pits under Compression Loading

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ABSTRACT

This study was conducted to investigate the mechanical behavior of apricot and cherry pits under compression loading along the three axial dimensions of the pits. The mechanical behavior was expressed in terms of force required to rupture of the pit, deformation at rupture point, deformation ratio (strain), energy absorbed and toughness. Also; masses and geometrical properties (axial dimensions, geometric mean diameter, sphericity and volume) of these pits were determined. These properties are necessary to design of cracking machines and knowledge amount of force and energy requirements for cracking operation. All experiments were carried out at moisture content of 9.81 and 12.92 %, (d.b.) for apricot and cherry pits, resp. The results showed that; the highest values of rupture force, deformation and energy required to crack the apricot pit were at loading position through the length axis, while; the lowest values were through the width axis, whereas; the highest values of rupture force, deformation and energy required to crack the cherry pit were at loading position through the thickness axis, while; the lowest values were through the width axis. In conclusion; the results obtained of the mechanical behavior of apricot and cherry pits indicated that; the compression through the width axis can be recommended for cracking process with minimum force and energy requirements.

Keywords: Apricot, cherry, pit, rupture force, deformation, energy absorbed, toughness

INTRODUCTION

Apricot and cherry fruits are classified under the *Prunus* genus, *Prunaidea* sub-family and the *Rosaceae* family of the Rosales group. Apricots (*Prunus armeniaca* L.) cultivates has mainly two types sweet and wild or bitter apricot *Kate et al., (2014)*. Also; the cherry cultivates has mainly two types of sweet cherry (*Prunus avium* L.) and sour (tart) cherry (*Prunus cerasus* L.) *Vursavuş et al., (2006)* and *Yılmaz et al., (2018)*. Globally, the total cultivated area of apricot and cherry crops about of 536,072 and 416,445 hectares with an annual production about of 4.25 and 2.44 million tons, resp. whereas the total cultivated area of sour cherry about of 188,888 hectares with an annual production about of 1.12 million tons. In Egypt the total cultivated area of apricot about of 6271 hectares with an annual production about of 96,226 tons according to *FAO, (2017)*. Generally; the fruit of cherry and apricot can be consumed fresh or dried fruits in addition; production of juice, jam, jelly, molasses and several types of soft drinks *Islam, (2002)* and *Fathollahzadeh et al., (2008)*. After food production from agricultural crops such as; fruits and vegetables there is high amount of waste or residual materials such as; stones, seeds, peels or husks, oilseed cake…etc., *Djilas et al., (2009)*. Both of apricot and cherry fruits contain of pit or stone, this pit consists of two main parts shell and kernel.

The shell of pit is composed of sclerenchyma and fiber matters, therefore; it is very hard and tough to break *Hassan-Beygi et al, (2009)*. The percentage of apricot and cherry seed (pit) based on fruit weight was 7.10 and 6.30 % by weight, resp. Also; the percentage of apricot and cherry kernel based on seed weight was 31.50 and 26.60 % by weight at moisture content of apricot and cherry kernels of 40.10 and 38.80, resp., *Kamel and Kakuda (1992)*.

The kernels of apricot and cherry contain dietary proteins and fiber, exhibit antioxidant and antimicrobial activities and may be used in the production of oils. The apricot and cherry kernel oil can be used in pharmaceutical, cosmetic and perfume industry or production of biodiesel. Oil extracted from the sweet apricot kernel is used for edible purpose while that of bitter apricot kernel is non-edible *Targais et al., (2011)*. Apricot and cherry kernels are good sources for production of oil. The bitter apricot kernel is a rich source of oil up to 54.21% *Dwivedi and Ram (2008)*.

While; the crude oil content of the dried cherry kernels about of 41.90 % *Kamel and Kakuda (1992)*. Bitter apricot kernels have more oil content than jatropha kernels, therefore; more yield can be produced from same cultivated area. The physicochemical properties of bitter apricot kernel biodiesel are almost like jatropha biodiesel; hence it can be used as blended fuel with mineral diesel in CI engines *Gurau and Sandhu (2018)*. *Demirbas, (2016)* mentioned that the biodiesel from kernel oil of sweet cherry seed is not significantly different from biodiesel produced from common vegetable oils.

Fruit stones/pits constitute a significant waste disposal problem for the fruit-processing industry *Lussier et al., (1994)*. The shell of apricot and cherry pits can be used as solid fuel in rural areas or production of activated carbon…etc. Activated carbon is an important industrial raw material, the apricot pits shell is production waste with wide source, low price and the shell quality of apricot pits is excellent. On the other hand, the raw material is featured with the hard texture, large surface area and strong adsorption *Zhu et al., (2013)*. Also; High-quality activated

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carbon can be produced from waste cherry stones: the activated carbon is low in impurities and has an adsorption capacity that compares favorably with commercial activated carbons *Lussier et al., (1994)*.

Tayel et al., (2011) reported that, average values of length, width, thickness and mass of apricot pits were 20.81, 17.44, 11.83 mm and 1.75 g, resp., at moisture content of 8 %, dry basis for the Egyptian 'Amar' variety. *Altuntas et al., (2018)* reported that, average values of length, width, thickness and mass of cherry pits were (12.17, 9.18, 7.97 mm and 0.371 g), (10.52, 7.85, 7.18 mm and 0.278 g) and (12.61, 8.24, 7.09 mm and 0.299 g) for three cherry laurel genotypes (54 K 01, 55 K 07 and 61 K 04) at moisture content of 27.16, 35.86 and 29.71 %, wet basis, resp.

The mechanical properties of apricot and cherry pits are very important in designing of suitable cracking machine for many uses previously mentioned of apricot and cherry pits (shell and kernel), in addition that the procedure of germination increasing when removing the shell of kernel (seed coat) of fruits pits such as apricot, cherry, plum, peach and so on. The minimum force requirement for pit cracking can be determined from important material properties, these properties found to influence pit cracking such as; pit size, variety and shell thickness *Kate et al., (2015)*. *Vursavuş and Özgüven (2004)* determined the mechanical behavior of apricot pits and concluded that the highest values of rupture force and energy requirements to crack apricot pits were at compression along the X-axis as compared to other two axes, while the lowest values of rupture force, deformation and toughness were obtained at loading along the Y-axis. *Ahmadi et al., (2008)* reported that the rupture force of fruit, pit and kernel were (8.23, 372.75 and 16.20 N) at loading position through length axis, (6.31, 297.34 and 32.25 N) through width axis and (5.87, 300.45 and 91.22 N) through thickness axis. *Hassan-Beygi et al., (2009)* found that the values of rupture force, deformation and toughness of the apricot pit along the X-axis always were more than the two other axes. Therefore, the pit compression along Y or Z axis at 0.30 (d.b.) moisture contents can be recommended for cracking operation with minimum force and energy requirements. *Kate et al., (2014"a")* determined the rupture force of the apricot pit along the X-axis was found to be 594.78 N and 568.96 N at two level of moisture content of 12 and 16 % (w.b.), resp.

Some physical properties of sweet cherry (*Prunus avium* L.) fruit were studied by *Naderiboldaji et al., (2008)*. *Vursavuş et al. (2006)* found that the length, width and weight of cherry pit were (9.87, 9.24 and 0.35), (9.78, 7.83 and 0.27) and (11.03 mm, 9.50 mm and 0.39 g) at moisture content of 78.25, 75.95 and 84.27 %, (d.b.) for three sweet cherry fruits varieties (Van, Noir De Guben and 0-900 Ziraat), resp. Rupture force of cherry laurel fruits decreased with increasing the moisture content from 9.0 to 77.5 %, (w.b.) *Çalişir and Aydin (2004)*. *Vursavuş et al., (2006)* found that the failure properties of three sweet cherry fruits varieties (Van, Noir De Guben and 0-900 Ziraat) such as force, stress, strain and modulus of elasticity were (13.67, 31.83, 0.26 and 120.97), (13.34, 38.29, 0.24 and 159.06) and (15.04 N, 33.97 kPa, 0.27 mm/mm and 125.24 kPa) at moisture content of 78.25, 75.95 and 84.27 %, (d.b.) resp. *Altuntas et al. (2018)* reported that the rupture force for cherry laurel fruits for Y-axis (0.740 N in 61 K 04 genotype) was higher than X- and Z-axes at moisture content of 64.13 %, (w.b.), while; the rupture force for cherry laurel fruits stone and kernel samples for X-axis (2.970 in 54 K 01 genotype, and 0.931 N in 61 K 04 genotype, resp.) were higher than Y and Z-axes at moisture content of 27.16 and 40.79 %, (w.b.) resp.

Knowledge of the mechanical behavior of apricot and cherry pits that provide useful information to agricultural engineers for optimum equipment design required to cracking of apricot and cherry pits with high efficiency and low damage for kernel. Therefore, the aim of this study was to determine the mechanical behavior [rupture force, deformation at rupture point, deformation ratio, energy absorbed and toughness] of apricot and cherry pits under compression loading along three axial dimensions of the pit, in addition to determine the masses and geometrical properties [axial dimensions, geometric mean diameter, sphericity and volume] of these pits, these properties are necessary to design and development of suitable cracking machines and knowledge amount of force and energy requirements for cracking operation.

MATERIALS AND METHODS

All experiments were carried out in the Laboratory of Agricultural Machinery & Power Engineering Department, Faculty of Agricultural Engineering, Al-Azhar University, Cairo, Egypt. Fresh apricot and cherry fruits were obtained from "El-Obour" market for trade of vegetables and fruits in Al-Qalyubia Governorate – Egypt. Pits of apricot and cherry fruits (Fig. "1") were manually separate from fruits then dried at ambient temperature. The moisture content [(M_C), %; dry basis] of apricot and cherry pits were determined by drying method in a hot air oven at 105 ± 3° C until a constant weight of sample according to *Hassan-Beygi et al., (2009)*. This test was repeated three times. The moisture content was estimated on dry basis using the following equation:

$$M_C = \frac{m_b - m_a}{m_a} \times 100 \;\ldots\ldots\ldots (1)$$

Where;

m_b and m_a mass of sample before and after heat treatment in (g), resp.

Fig. 1. Samples of apricot and cherry pits used in this study

A digital Caliper with accuracy of 0.01 mm was used to measure the three axial dimensions of randomly selected 100 pits for each of apricot and cherry pits. The three axial dimensions of pits are namely length "L, mm" (longest intercept), width "W, mm" (equatorial width perpendicular to L) and thickness "T, mm" (breadth perpendicular to L and W). The geometric mean diameter (D_g, mm), sphericity (∅, %) and volume (V_P, mm^3) of individual 100 pits for each of apricot and cherry pits were computed from the three axial dimensions (L, W and T) earlier measured according the following equations *Mohsenin, (1986).*

$$\mathbf{D_g = (L\,W\,T)^{\frac{1}{3}}} \quad \ldots\ldots\ldots(2)$$

$$\emptyset = \frac{\mathbf{D_g}}{\mathbf{L}} \times \mathbf{100} \quad \ldots\ldots\ldots(3)$$

$$\mathbf{V_p} = \frac{\pi}{6}\,(\mathbf{L\,W\,T}) \quad \ldots\ldots\ldots(4)$$

The mass (M, g) of individual 100 pits of each of apricot and cherry pits were randomly selected and weighed separately using a digital electrical balance with accuracy of 0.001g. A digital Universal Material Tester (Fig. "2") was used to investigate the mechanical behavior of apricot and cherry pits. The specifications of device were as follows: Model No: MT 20 21, range of the measurement is 0 to 20000 N and its accuracy is 0.01 N. The used sample of pits were 90 pits for each of apricot and cherry pits. This sample was divided to three groups (30 pits/group) for measure the rupture force and deformation at three axial dimensions (L "X", W "Y" and T "Z-axis") of pit. The individual pit was placed on the moving platform and compressed with a plate fixed by hydraulic system of material test device until the pit ruptured. The output data from the device was represented in a chart on the computer by software of the device.

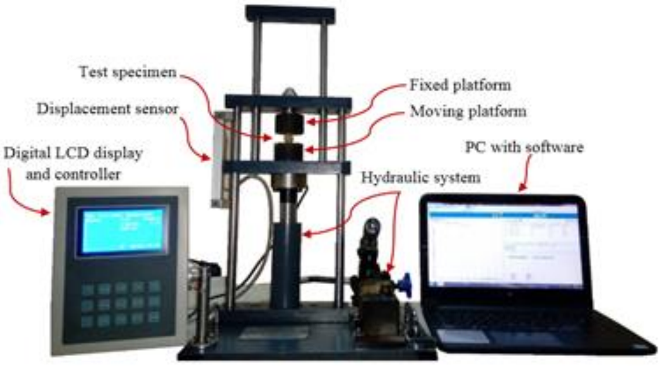

Fig .2.Universal Material Tester

The mechanical behaviors of apricot and cherry pits were expressed in terms of force required to rupture the pit, deformation at rupture point, deformation ratio, energy absorbed and toughness. Rupture force (F_R, N) is the minimum force required for crack the pit. Deformation (d, mm) at rupture point in loading direction. Deformation ratio (ε, mm/mm) is the axial strain under compression loading at rupture point of the pit and computed using the following equation *Sirisomboon et al., (2007)*; *Razavi and Edalatian (2012)* and *Mousa et al., (2016).*

$$\varepsilon_X = \frac{d_X}{L}, \quad \varepsilon_Y = \frac{d_Y}{W} \quad \text{and}$$

$$\varepsilon_Z = \frac{d_Z}{T} \ldots\ldots\ldots(5)$$

The energy absorbed (E_a, mJ) for rupture of pit is equivalent to the area under force-deformation curve between the initial point (0,0) and the rupture point. The value of energy absorbed was calculated by using the following equation according to *Altuntas et al., (2010)* and *Ardebili, et al., (2012).*

$$E_a = \frac{1}{2}\,F_R\,d \quad \ldots\ldots\ldots(6)$$

Toughness (P, mJ/mm^3) is defined as the energy absorbed by the pit up to the rupture point per unit volume of the pit, the value of toughness was calculated by using the following equation *Olaniyan and Oje, (2002).*

$$\mathbf{P} = \frac{\mathbf{E_a}}{\mathbf{V_P}} \ldots\ldots\ldots.(7)$$

The data obtained were subjected to descriptive statistics such as; range (minimum "Min" and maximum "Max"), mean, standard deviation (SD) and coefficient of variation (CV) by using spread sheet software program (Microsoft Excel).

RESULTS AND DISCUSSION

All the experiments were carried out under the moisture contents of 9.81 ± 0.09 and 12.92 ± 0.12 % (d.b.) with coefficient of variation (CV) of 0.96 and 0.91% for apricot and cherry pits, resp. The results obtained showed that the values of masses ranged from 1.01 to 1.76 and 0.18 to 0.38 g with the mean values of 1.35 ± 0.15 and 0.26 ± 0.04 g for apricot and cherry pits, resp., as shown in Table (1).

Table 1. Masses and geometrical properties of apricot and cherry pits.

Parameter		Apricot pits			Cherry pits		
		Mean	SD	CV	Mean	SD	CV
M, (g)		1.35	± 0.15	10.80	0.26	± 0.04	16.96
Axial dimensions, (mm).	L	20.38	± 0.87	4.24	10.78	± 0.73	6.79
	W	15.88	± 0.82	5.14	8.69	± 0.52	5.99
	T	10.73	± 0.50	4.63	6.79	± 0.41	5.98
D_g, (mm)		15.14	± 0.61	4.01	8.60	± 0.41	4.81
∅, (%)		74.29	± 1.74	2.35	79.93	± 4.07	5.10
V_P, (mm^3)		1824.85	± 219.79	12.04	334.93	± 48.10	14.63

The highest and lowest values of length, width and thickness were [(22.15, 18.55 and 12.10 mm) and (18.36, 13.89 and 9.28 mm)] for apricot pits and [(12.55, 10.02 and 7.72 mm) and (9.03, 7.41 and 5.79 mm)] for cherry pits, resp. Whereas; the mean values of length, width and thickness of apricot and cherry pits were (20.38, 15.88 and 10.73 mm) and (10.78, 8.69 and 6.79 mm), resp. Also; the results indicated that the values of geometric mean diameter ranged from 13.78 to 16.87 mm with mean of 15.14 ± 0.61 mm and 7.33 to 9.72 mm with mean of 8.60 ± 0.41 mm for apricot and cherry pits, resp. The values of sphericity ranged from 70.11 to 77.89 % with mean of 74.29 ± 1.74 % and 69.06 to 89.46 % with mean of 79.93 ± 4.07 % for apricot and cherry pits, resp; this result is an indication that the shape of apricot and cherry pits are close to the ellipsoidal shape, for the ellipsoidal shape of material, the volumes of individual apricot and cherry pit were calculated by using equation (4) in materials and methods. Knowledge of shape and physical dimensions are important in screening solids to separate foreign materials and in sorting and sizing of fruits and pits *Naderiboldaji et al., (2008).* Also; the results indicated that the volumes of apricot and cherry pits ranged from 1369.68 to 2513.44 mm^3 with mean of 1824.85 mm^3 and 206.14 to 481.01 mm^3 with mean of 334.93 mm^3, resp.

1. Rupture force

Table (2) shows the values of rupture force for apricot and cherry pits at three axial dimensions [X-axis (Length), Y-axis (Width) and Z-axis (thickness)]; the results showed that, the values of rupture force for apricot pits along X, Y and Z-axes ranged from 629.87 to 1223.41, 231.91 to 464.75 and 410.02 to 704.08 N, resp. The results indicated that, the rupture force of apricot pit at loading position through the width had the lowest value with mean of 334.38 N followed by the thickness with mean of 567.25 N; while, the length had the highest value of the rupture force with mean of 889.13 N, similar trend of this result was observed by *Ahmadi et al., (2008)* for apricot pits. From Table (2) the results showed that, the values of rupture force for cherry pits along X, Y and Z-axes ranged from 102.97 to 415.58, 113.17 to 368.27 and 174.40 to 415.95 N, resp. The results indicated that, the rupture force of cherry pit at loading position through the width had the lowest value with mean of 229.78 N; while, the thickness had the highest value of rupture force with mean of 316.00 N.

Table 2. Values of rupture force at three axial dimensions for apricot and cherry pits.

Parameter			Range		Mean	SD	CV, (%)
			Min.	Max.			
Rupture force, (N).	Apricot Pits	F_{R-X}	629.87	1223.41	889.13	± 146.62	16.49
		F_{R-Y}	231.91	464.75	334.38	± 57.70	17.26
		F_{R-Z}	410.02	704.08	567.25	± 68.58	12.09
	Cherry Pits	F_{R-X}	102.97	415.58	243.85	± 103.77	42.56
		F_{R-Y}	113.17	368.27	229.78	± 68.59	29.85
		F_{R-Z}	174.40	415.95	316.00	± 58.03	18.36

2. Deformation and deformation ratio at rupture point.

Table (3) shows the values of deformation and deformation ratio (compression strain) for apricot and cherry pits at three axial dimensions. From Table (3) the values of deformation at rupture point for apricot pits ranged from 1.38 to 2.69 mm with mean of 2.07 mm, 0.38 to 1.32 mm with mean of 0.71 mm and 1.29 to 2.05 mm with mean of 1.67 mm at loading position through length, width and thickness axes, resp.; this result indicates that the mean value of deformation for apricot pit compressed through the length axis is higher than other two axes; this result is agreement with *Vursavuş and Özgüven (2004)*, the reason for this trend is that the apricot pit is more flexible and is more resistant to rupturing along the X-axis as compared to the other two axes. For cherry pits; the values of deformation at rupture point ranged from 0.26 to 1.86 mm with mean of 0.79 mm, 0.25 to 1.51 mm with mean of 0.67 mm and 0.47 to 1.27 mm with mean of 0.90 mm at loading position through length, width and thickness axes, resp.

Table 3. Values of deformation and deformation ratio at rupture point for apricot and cherry pits at three axial dimensions.

Parameter			Range		Mean	SD	CV, (%)
			Min.	Max.			
Deformation, (mm).	Apricot Pits	d_X (L)	1.38	2.69	2.07	± 0.33	16.10
		d_Y (W)	0.38	1.32	0.71	± 0.18	25.58
		d_Z (T)	1.29	2.05	1.67	± 0.19	11.42
	Cherry Pits	d_X (L)	0.26	1.68	0.79	± 0.37	46.62
		d_Y (W)	0.25	1.51	0.67	± 0.25	37.06
		d_Z (T)	0.47	1.27	0.90	± 0.21	22.86
Deformation ratio, (mm/mm).	Apricot Pits	ε_X (L)	0.07	0.12	0.10	± 0.01	14.13
		ε_Y (W)	0.03	0.08	0.04	± 0.01	24.50
		ε_Z (T)	0.12	0.19	0.16	± 0.02	10.06
	Cherry Pits	ε_X (L)	0.03	0.16	0.07	± 0.03	43.87
		ε_Y (W)	0.03	0.15	0.08	± 0.02	32.82
		ε_Z (T)	0.07	0.18	0.13	± 0.03	21.67

The deformation at rupture point is useful to determine the clearance required to crack the pit, *Lim, et al. (2014)* determined the clearance required to cracking of Jatropha fruits, the value of minimum clearance equal value of fruit width mins value of deformation at rupture point as preliminary test for cracking process. The results showed that the values of deformation ratio at rupture point for apricot pits ranged from 0.07 to 0.12 with mean of 0.10 mm/mm, 0.03 to 0.08 with mean of 0.04 mm/mm and 0.12 to 0.19 with mean of 0.16 mm/mm at loading position through length, width and thickness axis, resp. While; the values of deformation ratio at rupture point for cherry pits ranged from 0.03 to 0.16 with mean of 0.07 mm/mm, 0.03 to 0.15 with mean of 0.08 mm/mm and 0.07 to 0.18 with mean of 0.13 mm/mm at loading position through length, width and thickness axis, resp. The previously values of deformation ratio at the rupture point indicates compression strain required to rupture the pit.

3. Energy absorbed and toughness.

Table (4) shows the values of energy absorbed and toughness at rupture point for apricot and cherry pits at three axial dimensions. The results showed that; the compression along the X-axis (length) required more energy for the rupture of the pit than other two axes for apricot pits, while; compression along the Z-axis (thickness) required more energy for the rupture of the pit than other two axes for cherry pits. The average highest values of rupture energy and toughness (energy absorbed per unit volume) for apricot pits were at loading position through length axis with mean of 933.05 mJ and 0.487 mJ/mm^3, resp. While; the average lowest values of rupture energy and toughness were at loading potion through width axis with mean of 121.02 mJ and 0.066 mJ/mm^3, resp. The result of apricot pit toughness is agreement with *Vursavuş and Özgüven (2004)* and *Hassan-Beygi et al., (2009)*. For cherry pits, the average highest values of rupture energy and toughness were at loading position through thickness axis with mean of 147.27 mJ and 0.453 mJ/mm^3, resp. While; the average lowest values of rupture energy and toughness were at loading position through width axis with mean of 83.32 mJ and 0.234 mJ/mm^3, resp. The previously values of rupture energy for apricot and cherry pits indicate how easily the pit can be broken.

Table 4. Values of energy absorbed and toughness for apricot and cherry pits at three axial dimensions.

Parameter			Range		Mean	SD	CV, (%)
			Min.	Max.			
Energy absorbed, (mJ).	Apricot Pits	E_{a-X}	434.61	1520.80	933.05	± 265.62	28.47
		E_{a-Y}	44.06	254.08	121.02	± 44.53	36.79
		E_{a-Z}	297.26	704.08	476.69	± 97.97	20.55
	Cherry Pits	E_{a-X}	13.39	311.69	110.78	± 87.41	78.91
		E_{a-Y}	14.73	233.23	83.32	± 51.43	61.72
		E_{a-Z}	40.98	260.95	147.27	± 55.52	37.70
Toughness, (mJ/mm^3).	Apricot Pits	P_X	0.285	0.728	0.487	± 0.11	23.28
		P_Y	0.027	0.141	0.066	± 0.02	34.39
		P_Z	0.153	0.424	0.271	± 0.05	19.43
	Cherry Pits	P_X	0.048	0.829	0.304	± 0.22	71.44
		P_Y	0.071	0.630	0.243	± 0.14	58.37
		P_Z	0.136	0.822	0.453	± 0.16	36.22

CONCLUSION

This study focused on the mechanical behavior [rupture force, deformation, deformation ratio, energy absorbed and toughness] of apricot and cherry pits under compression loading at three axial dimensions [L (X), W (Y) and T (Z-axis)] of the pit, also; masses and geometrical properties (axial dimensions, geometric mean diameter, sphericity and volume) of these pits were determined. All experiments were carried out at moisture content of 9.81 and 12.92 % dray basis for apricot and cherry pits, resp. The important obtained results from this study can be summarized as follows:

- The results showed that, the mean values of mass, length, width, thickness, geometric mean diameter, sphericity and volume of apricot and cherry pits were (1.35 g, 20.38 mm, 15.88 mm, 10.73 mm, 15.44 mm, 74.29 % and 1824.85 mm^3) and (0.26 g, 10.78 mm, 8.69 mm, 6.79 mm, 8.60 mm, 79.93 % and 334.93 mm^3), resp. Also; the results revealed that; the values of sphericities are an indication that the shape of apricot and cherry pits are close to the ellipsoidal shape.
- The results revealed that; the mean values of rupture force, deformation, deformation ratio, energy absorbed and toughness at three axes X, Y and Z-axis were [(889.13, 334.38 and 567.25 N), (2.07, 0.71 and 1.76 mm), (0.10, 0.04 and 0.16 mm/mm) (933.05, 121.02 and 476.69 mJ) and (0.487, 0.066 and 0.271 mJ/mm^3)] for apricot pits, and [(243.85, 229.78 and 316.00 N), (0.79, 0.67 and 0.90 mm), (0.07, 0.08 and 0.13 mm/mm) (110.78, 83.32 and 147.27 mJ) and (0.304, 0.243 and 0.453 mJ/mm^3)] for cherry pits, resp.
- For the apricot pits; the highest average values of rupture force, deformation and energy required to crack the pit were at loading position through the length axis, while; the lowest values were through the width axis.
- For the cherry pits; the highest values of rupture force, deformation and energy required to crack the pit were at loading position through the thickness axis, while; the lowest values were through the width axis.
- In conclusion; the results obtained of the mechanical behavior of apricot and cherry pits indicated that; the compression through the width axis can be recommended for cracking process with minimum force and energy requirements.

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السلوك الميكانيكي لأنوية ثمار المشمش والكرز تحت حمل الضغط

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ثمار المشمش والكرز يتبعان الفاكهة ذات الأنوية الحجرية وهاتين الثمرتين تتميزان بأن لهما فوائد غذائية وصحية مرتفعة لإحتوائهما على مضادات الأكسدة، الفيتامينات، الألياف والمعادن الهامة والضرورية لجسم الإنسان. وينتج من هاتين الثمرتين أنوية تحتاج إلى عملية التكسير للإستفادة من اللب الموجود داخل هذه الأنوية - حيث يستخدم اللب لأغراض متعددة سواء في عملية الزراعة لإنتاج أصناف الشتلات المختلفة أو لإستخلاص الزيوت لإستخدامها في صناعة العقاقير، مستحضرات التجميل و الروائح العطرية بالإضافة إلى إمكانية إستخدام هذا الزيت كوقود حيوي. أما قشر الأنوية فقد يستخدم كوقود صلب أو كسماد عضوي أو في إنتاج الكربون النشط لما له من فوائد وإستخدامات عديدة في المجالات الطبية، والصناعية، ومجال حماية البيئة كتنقية الماء والهواء. ولإجراء عملية تكسير الأنوية الحجرية ميكانيكيا بكفاءة عالية وبأقل ضرر ممكن - يجب أولاً معرفة السلوك الميكانيكي لأنوية هذه الثمار - لذلك يهدف هذا البحث إلي دراسة السلوك الميكانيكي (قوة الكسر، التشوه، نسبة التشوه/الإنفعال، الطاقة المطلوبة للكسر والمتانة) لأنوية ثمار المشمش والكرز تحت حمل الضغط خلال الأبعاد المحورية (الطول، العرض و السمك) بالإضافة لتحديد الكتلة والخصائص الهندسية (الأبعاد المحورية، القطر الهندسي، والكروية و الحجم) – وذلك لتوفير البيانات المطلوبة لتصميم وتطوير آلات التكسير المناسبة وكذلك معرفة مقدار القوة والطاقة اللازمة لإجراء عملية التكسير – جميع التجارب أجريت عند محتوى رطوبي ٩,٨١ و١٢,٩٢ ٪ على أساس جاف لأنوية ثمار المشمش والكرز على التوالي. وكانت أهم النتائج المتحصل عليها كالتالي: متوسط قيم الكتلة ، الطول ، العرض ، السمك ، القطر الهندسي ، الكروية و الحجم [(١,٣٥ جم ، ٢٠,٣٨ مم ، ١٥,٨٨ مم ، ١٠,٧٣ مم ، ١٥,٤٤ مم ، ٧٤,٢٩ ٪ و ١٨٢٤,٨٥ مم^3) لأنوية ثمار المشمش] و [(٠,٢٦ جم ، ١٠,٧٨ مم ، ٨,٦٩ مم ، ٦,٧٩ مم ، ٨,٦٠ مم ، ٧٩,٩٣ ٪ ، ٣٣٤,٩٣ مم^3) لأنوية ثمار الكرز] على التوالي. متوسط قيم قوة الكسر ، التشوه ، نسبة التشوه ، الطاقة المطلوبة للكسر و المتانة بالنسبة لمحور الطول والعرض والسمك [(٨٨٩,١٣ ، ٣٣٤,٣٨ و ٥٦٧,٢٥ نيوتن) ، (٢,٠٧ ، ٠,٧١ و ١,٧٦ مم) و (٠,١٠ ، ٠,٠٤ و ٠,١٦ مم/مم)، (٩٣٣,٠٥ ، ١٢١,٠٢ و ٤٧٦,٦٩ مللي جول) و (٠,٤٨٧ ، ٠,٠٦٦ و ٠,٢٧١مللي جول/مم^3) لأنوية ثمار المشمش] و [(٢٤٣,٨٥ ، ٢٢٩,٧٨ و ٣١٦,٠٠ نيوتن) ، (٠,٧٩ ، ٠,٦٧ و ٠,٩٠ مم) و (٠,٠٧ ، ٠,٠٨ و ٠,١٣ مم/مم) ، (١١٠,٧٨ ، ٨٣,٣٢ و ١٤٧,٢٧ مللي جول) و (٠,٣٠٤ ، ٠,٢٤٣ و ٠,٤٥٣ مللي جول/مم^3) لأنوية ثمار الكرز] على التوالي.
أعلى قيمة متوسطة لقوة الكسر ، التشوة والطاقة المطلوبة لكسر النواة كانت عند وضع التحميل خلال محور الطول لنواة ثمرة المشمش و محور السمك لنواة ثمرة الكرز و أقل قيمة لهما كانت عند وضع التحميل خلال محورالعرض .لذا توصي الدراسة بإجراء الضغط خلال محور العرض لإجراء عملية التكسير لكلاً من أنوية ثمار المشمش والكرز وذلك بأقل قوة وطاقة مطلوبة.