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Physical Properties of Barhi dates at khalal stage, study area (Baghdad city)

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Abstract

In this research, the physical properties of l Barhi dates at khalal stage such as mass, length, width, thickness, geometric and arithmetic mean diameter, aspect ratio, true volume, apparent volume, sphericity, surface area, true density, bulk density, and porosity were studies. These physical properties for fruits are useful in packaging food, equipment design, storage, handling, and quality assessment for the fruits where the consumers often chooses the fruits on the basis of their inclusion , size, and rest of other physical properties. The results showed that these properties reached 15.07g, 32.21 mm, 26mm, 23.05mm, 26.81mm, 27.08mm, 71.92%, 14.57cm2 , 8.50 cm2 , 83.43%, 22.60 cm2 (McCabe) , 20.01 cm2 (Jean& Ball), 1.03 g. cm-3, 0.47 g. cm-3, 54.40%, respectively. The 50% of length values ranging from 31.00- 32.00mm, 90% of width values from 26.00-26.20 mm, 70% of thickness values from 23.00-23.17mm and, 75% of mass values from 14.95-16.15mm. The results showed the high relation was between the length and sphericity for fruits while not statistically significant between length and width and between geometric and arithmetic mean diameter. Colour components for fruits (L*, b* and a*) were 53.81, 41.66, 4.51, respectively. Moreover, the coefficient of friction at using, plywood, glass and galvanized iron steel was 0.35, 0.24 and 0.30.

Keywords: *Barhi dates, Khalal, colour, coefficient of friction، Physical properties.*

Introduction

Date Palm (*Phoenix dactylifera L.)* is the more common in the central and Southern region of Iraq, where its history in this place dates back to (4000 BC) [1]. Date tree is in the religious culture of Muslims is considered a sacred tree, as it was mentioned in the Qur'an and ancient texts indicate that the Sumerians in Iraq the first planted this tree 4,000 years ago BC [2]. Iraq depends on the central statistical organization has an annual production about 646,163 tons of dates and has 15139076 trees for the year 2018[3]. Dates are the main fruit in Iraq and most Arab countries. In terms of its nutritional importance to humans, dates are an

important origin of energy, due to their high content of carbohydrate (70–80%). In addition, dates contain protein (2.30–5.60%), fat (0.20– 0.50%), minerals (0.10–916 mg/100 g dry weight), dietary fiber (6.40–11.50%), vitamins for example (A, B1, B2, B3, & C) [4] [5].

In addition to eating it as a fruit, it is used in many other food industries such as pastries, date syrup and many products of date processing such as organic acids, exo-polysaccharides and others. Iraq produces about 646,163 tons of dates and has 15139076 trees for the year 2018[3]. The fruit of the date palm goes through five stages until it becomes mature, these stages according to the Arabic words are: Hababouk, Kimri, Khalal or Bisir, Rutab and Tamar [5]. The most types of dates are eaten and marketed at Rutab and Tamar stage [6]. Some of dates types are ready to sell and eaten at Khalal stage such as Barhi, Bream, Maktoum since they have become of sweet taste and crunchy at this stage. Compared to other types، Barhi dates one of the most famous types of these dates, especially the Iraqi one, which export to other countries Fig1 [6]. Therefore, it is critical to examine the physical properties of such type of dates for designing machines processing, transportation machines, handling, and packaging, and storage, assessment of fruit quality. Furthermore, in the later period, several techniques will be tried to extend the shelf life of Khalal stage for these dates (Barhi) such as Modified atmosphere storage, vacuum packaging and hydrochooling [7]. These techniques require the study of some of these physical properties before and after the storage with these techniques [8]. The purposes of this research is the physical properties which are examined in this study include: colour, weight, length, width, thickness, sphericity, true and apparent volume, surface area, True and bulk density, geometric and arithmetic mean diameter, aspect ratio, and porosity.

The aim of study the physical properties of khalal Barhi dates to Providing a database for the classification of Barhi dates based on quality standards and a better design for sorting, grading and processing machines, as well as choosing storage and packaging methods. Many studies have been reported on the physical properties of fruits, grains and seeds, such as Juniperus drupacea fruits [9], Bambara groundnuts [10].

2. Materials and Methods

2.1. Materials

Five kg of Barhi fruits at khalal stage were obtained from the palm orchards of the city of Baghdad during the fifteenth of august before the beginning of hydration then transferred to the Date palm lap in college of agriculture / university of Baghdad. 100 fruits were gathered randomly for the testing at room temperature. The moisture content of the fruits was obtained by choosing five fruits at random from sample and then drying them at 105℃ for 3 days in an oven and the moisture content calculated by the difference between the weight of fruit before and after drying and then find the moisture content of the five fruits [11].

Nomenclature

L	length of fruit ,mm	M	unit mass of seed, g
R	aspect ratio, %	W	width of fruit, mm
S	surface area, mm^2	T	thickness of fruit, mm
Va	apparent volume, cm^3	Dg	geometric mean diameter ,mm
Vt	true volume, cm^3	Da	arithmetic mean diameter, mm
R_a	aspect ratio, %	ϕ	sphericity, %
ρ_t	true density, g/m^3	P	porosity, %
ρ_b	bulk density, g/m^3		

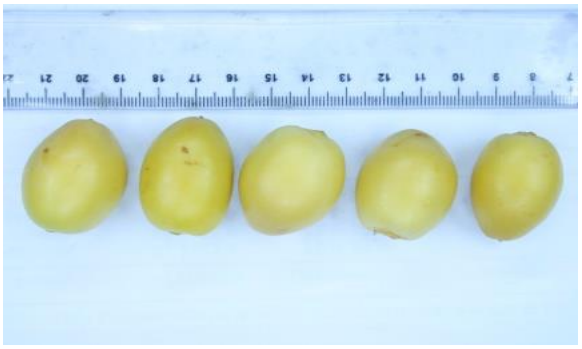


Fig1 Sample of Barhi dates at khalal stage

2.2. Methods

2.2.1. Physical properties measurement

Mass of fruit was measured with an electronic balance with a sensitivity of 0.01g (ML3002.E, Mettler Toledo, Switzerland). As for Length (L), Thickness (T) and Width (W) were measured by using a micrometer (Tuff 0.01mm). The sphericity, geometric mean diameter(D_g), and arithmetic mean diameter (D_a) were determined by the following equations. The calculated values are the average values of 100 fruits [10].

$$\phi = \frac{(LWT)^{0.333}}{L} \quad (1)$$

$D_a = \frac{(L+W+T)}{3}$

(2)

$D_g = (LWT)^{1/3}$

(3)

The surface area (S) of fruit is expressed by the equation of McCabe *et al.* (1978) & Jean & Ball, (1997)*:*

$S = \pi D_g^{\ 2}$

(4)

$S = \frac{\pi BL^2}{2L-B}$

(5)

Where $B=(WT)^{0.5}$

The apparent volume (V_a) is calculated theoretically by calculation (Jain and Bal, 1997), and true volume (V_t) is calculated by the liquid displacement method [11] :

$V_a = \frac{\pi B^2 L^2}{6(2L-B)}$

(6)

Aspect ratio (Ra) is determined by (Maduako & Faborode, 1990):

$\%R_a = \frac{W}{L} \times 100$

(7)

True density (ρ_t) is measured by the following equation [14] :

$\rho_t = \frac{Ma}{V_t}$

(8)

The bulk density (g. cm^{-3}) is obtained by a container with known mass and measured the volume which filled with the Barhi fruits. The bulk density is determined by the ratio of date mass in the container to its volume [15]:

$\text{Bulk density} = \frac{\text{Sample Weight}}{\text{Volume}}$

(9)

The porosity of bulk is determined by [12]:

$\%\varepsilon = (1 - \frac{\rho_b}{\rho_t}) \times 100$

(10)

2.2.2. Colour measurement

The colour was measured by using a Hunterlab Colour Model 45*0* (made in the USA) which lightness (*L**), with *L** values ranging from 0 (black) to 100 (white); 'b*' values ranges from –100 (blueness) to + 100 (yellowness), and the '*a**' value ranges from -100 (greenness) to + 100 (redness) [21].

3. Statistical Analysis

The Statistical analysis in this study was carried out by used Microsoft excel software. Trends considered significant whereas the means of compared sets differed at $P < 0.05$ (Student's t-test) [8].

4. Results and Discussion

The physical properties of Barhi khalal dates are shown in Table1. The results show that the length, width, thickness, and mass of fruits ranged between 29.2- 38, 24-28, 20.21-26.112.77-18.08mm, respectively. These dimensions are

important when designing the aperture's size of the separation machines, packing boxes, and, evaluating fruit quality [12]. The aspect ratio ranges between 62.36-82.85 %. These results show that the relation of width to the length is an indication of its tendency towards being spherical, and this is one of the distinguishing physical properties of Barhi dates compared to other varieties of date fruits.

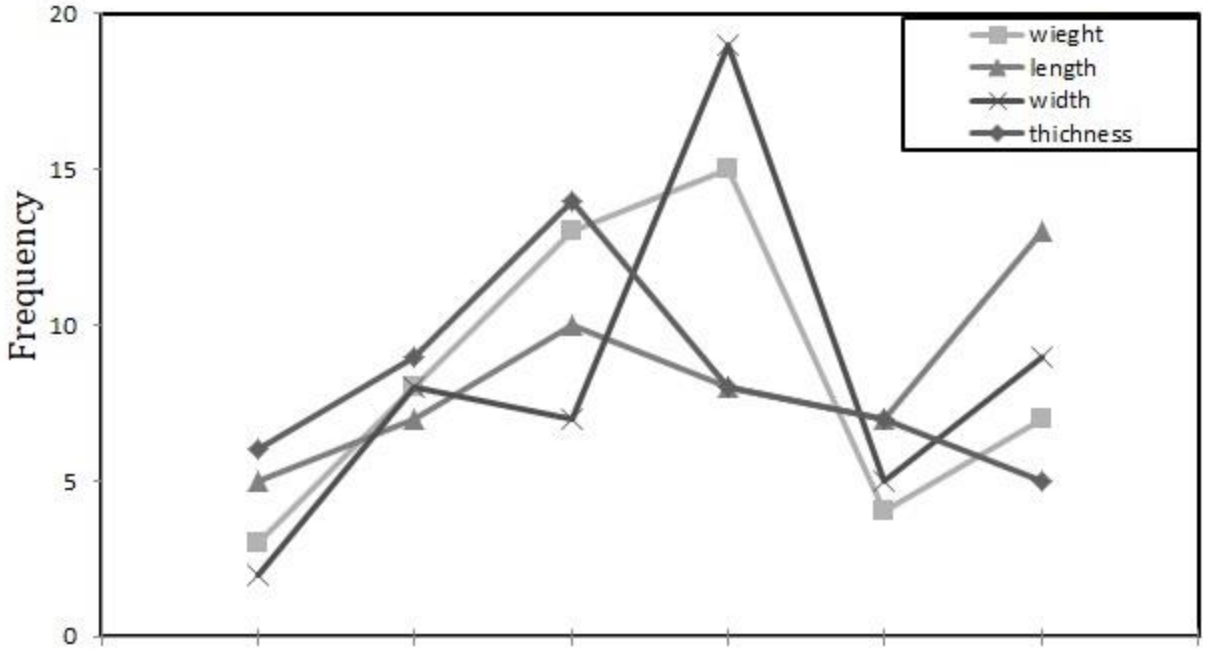
The frequency distribution curves are shown in Fig2. The 50% of length ranging from 31.00- 32.00mm, 90% of width from 26.00-26.20 mm, 70% of thickness from 23.00-23.17 mm and, 75% of mass from 14.95-16.15mm, moreover the largest repetition were: 34-38mm, 26.00-26.20mm, 25.00-26.10 mm, 14.95-16.15 g, respectively. The following expression can be used to appear the relationship between *L, W, T*, and, *M* of Barhi khalal dates:

$$L = 1.23W = 1.39T = 2.02M \quad (11)$$

Table 1 The physical properties of Barhi date fruits

Attribute	Number of observation	Replication	Minimum value	Maximum value	Mean value	Standard deviation	Range
Moisture Content	%	5	58.04	68.08	63.64	3.25	30.04
Length	mm	100	29.2	38	32.21	2.17	8.8
Width	mm	100	24	28	26	0.78	4
Thickness	mm	100	20.21	26.1	23.05	1.24	5.89
Mass	g	100	12.77	18.08	15.07	1.32	5.31
Geometric mean diameter	mm	100	24.74	28.60	26.81	1.02	3.86
Arithmetic mean diameter	mm	100	25.07	30.16	27.08	1.07	5.09
Sphericity	%	100	77.38	90.30	83.43	3.50	12.92
Surface area(McCabe)	cm^2	100	19.23	27.67	22.60	1.73	8.44
Surface area(Jean& Ball)	cm^2	100	17.12	22.58	20.01	1.46	5.46
Apparent volume	cm^2	100	6.67	10.84	8.50	0.85	4.17
True volume	cm^2	100	12	16.5	14.57	1.25	4.5
Aspect ratio %	%	100	62.36	82.85	71.92	4.85	20.49
Apparent density	g. cm^{-3}	100	1.50	2.09	1.77	0.14	1.59
Bulk density	g. cm^{-3}	5	0.42	0.51	0.47	0.31	0.09
True density	g. cm^{-3}	100	0.96	1.13	1.03	1.05	0.17
Porosity	%	5	52.03	58.37	54.40	2.79	6.34
Colour properties							
L*		5	52	55.77	53.81	1.01	3.77
a*		*5*	4.30	5.24	4.51	0.38	0.94
b*		*5*	39.92	43.79	41.66	1.44	3.87
Static Coefficient of friction							
Plywood	%	5	0.31	0.41	0.35	0.04	0.1
Glass	-	5	0.22	0.27	0.24	0.01	0.02
Galvanized iron steel	-	5	0.27	0.34	0.30	0.02	0.07

The geometric and arithmetic mean diameter for fruits ranges were between 28.60-24.74 and, 30.16-25.07, respectively. The sphericity and surface area of Barhi date fruit ranges between 77.38-90.30, 19.23-27.67(McCabe), 17.12-22.58(Jean & Ball), respectively. (Table1). The values of sphericity were higher than the results reported for the Daire date and, two varieties of Algerian dates [16] [17]. This property of Barhi khalal dates corrects easy slip-on flat surface and, this tendency to either roll or slide should be necessary for the design the transmission machinery, also will be an indication of the way the fruits will behave on surfaces during processing



M, g	12.51-13.17	13.17-13.97	13.97-14.95	14.95-16.15	16.15-16.54	16.5418.08
L, mm	28.02-29.80	29.80-31.00	31.00-32.00	32.00-33.00	33.00-34.00	34.00-38.00
W, mm	24.00-25.00	25.00-25.50	25.50-26.00	26.00-26.20	26.20-27.00	27.00-28.00

Fig. 2. Frequency distribution for the dimensions of fruits.

The true and apparent volume, true and bulk density and porosity ranges were 12-16.5 cm^2, 6.67-10.84 cm^2, 0.96-1.31 g. cm^{-3}, 1.50-2.09 g. cm^{-3}, 0.42-0.51 g. cm^{-3}, 52.03-58.37%, respectively. (Table1).

Volume is a parameter that affecting consumer acceptance for Barhi khalal dates, therefore the larger volume means more acceptance to the consumers. The bulk density of Barhi khala dates is a useful tool in the storage places. On the other hand, the porosity shows the degree of pore in the biological material mass [18] [19].

The values of true density showed that most fruit density is lower than water which is the important property during wet cleaning and hydrodynamic transportation, because the fruit will sink in water. These properties will be useful in the transportation and separation of the fruits by hydrodynamic means.

The yellow colour is one of the physical characteristics of Barhi dates at the khalal stage it is clearly shown from the values (*l**) and *(b*)* (Table1). This characteristic is very usually a main factor for the consumers preference because the Barhi dates at khalal stage begin to lose this yellow colour when they move to rutab stage and decreased values (*l**) and *(b*)* and increased values *(a*)*. [8].

The Correlation coefficients for L/W, L/M, L/T, L/S, L/Dg, and, L/Φ are showed in

(Table.2.). The relations between L/M, L/T, L/S, L/Dg and, L/Φ are statistically significant while L/ W is not statistically significant.

Table 2 The correlation coefficient of Barhi date fruit.

Particulars	Ratio	Degree of freedom	Correlation coefficient *(R)*
L/W	1.23	48	.177
L/T	1.39	48	.376**
L/M	2.02	48	.538**
L/ϕ	0.38	48	-.840**
L/S (McCabe)	1.42	48	.808**
L/S(Jean& Ball)	1.61	48	.647**
L/D_g	1.20	48	.807**

**.Correlation is significant at the 0.01 level (2-tailed).

*.Correlation is significant at the 0.05 level (2- tailed).

The coefficient of static friction of Barhi khalal dates is 0.35 on plywood, 0.30 on galvanized iron steel and, 0.24 on glass (Table 3).

Table3 Static Coefficient of friction of Barhi dates fruits on different surfaces

Attribute	Unit of measurement	Replication	Minimum value	Maximum value	Mean value	Standard deviation	Range
Plywood	%	5	0.31	0.41	0.35	0.04	0.1
Glass	-	5	0.22	0.27	0.24	0.01	0.02
Galvanized iron steel	-	5	0.27	0.34	0.30	0.02	0.07

This means that the forces of friction on the glass surface are generally lower than plywood and galvanized iron steel surfaces. The coefficient of friction is most important in selecting convenient materials for different units of machinery that required transport of fruits [20].

5. CONCLUSION

Khalal Barhi dates are one of the best varieties of dates which are eaten and exported to various countries. Wherefore the physical properties such as volume, density, dimensions, and colour are very important in evaluation the quality of fruit and thus determining the price based on these qualities. Moreover, these properties allow us to differentiate between khalal and Rutab stages for this fruit. Designing converting, handling, cleaning machinery and packaging boxes require precision in design due to the range of fruits dimensions and volume. Knowledge of these properties will also be useful in determining the success of cold storage or modified atmosphere packaging and storage operation that are currently used for the purpose of prolonging khalal stage for these fruits and the design of the machines involved will be facilitate.

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