



## EVALUATION OF PHYSICAL, CHEMICAL AND MICROBIAL PROPERTIES OF DATE FRUIT SEEDS

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### Abstract

*Agriculture sector plays a pivotal role in Nigeria's economic development, necessitating the grading of agricultural products based on size. Grading of date seeds are essential for proper handling, processing, storage, and value addition. To develop appropriate processing technologies, understanding the engineering properties of agricultural products is crucial. Hence, studying the engineering properties of date seeds is imperative. The physical, chemical, and microbiological characteristics of red and yellow date seed variants were ascertained in this study. Physical properties examined encompassed mass, length, width, thickness, volume, geometric mean diameter, arithmetic mean diameter, sphericity, and surface area. For the yellow date seed variety, its mass ranged from 0.85g to 3.01g, while for the red variety it mass ranged from 0.99g to 1.76g. Similarly, length, width, and thickness exhibited varying ranges for both varieties. The arithmetic and geometric mean diameters also displayed distinct ranges for each variety. Chemical properties such as moisture, ash, protein, carbohydrate, fat, and crude fibre content were assessed. Moisture content was found to be 4.87% and 5.76% for the red and yellow varieties, respectively. The red and yellow types had an ash level of 1.05% and 1.08%, respectively. Protein, carbohydrate, fat, and crude fibre content also varied between the two varieties. Moreover, the microbial properties analysis revealed that the study of ethanol in dates could serve as a natural food preservation method, potentially yielding health-protective compounds with antimicrobial activity.*

**Keywords:** *Date seeds, moisture content, physical properties, chemical properties, ethyl-acetate extract*

### Introduction

Food plays an essential role in growth and development, providing vital nutrients for energy across different age groups. A balanced diet fosters healthy aging and disease resistance, while nutrient deficiencies lead to health problems. Potential exists for new products, interventions, and precise dietary guidelines to improve health through nutrition awareness. Recognising this potential underscore, the importance of meeting dietary needs. Enhancing food processing techniques is key (Food, Nutrition and Health, 2020).

The engineering properties of seeds encompass a vast body of information that can be applied to farming, harvesting, storing, and processing. When developing processing machinery, this is crucial. Understanding the physical characteristics of seed materials is necessary for accurate machine design. Taking into account the agricultural material in bulk or in individual units, in order to accurately estimate its shape, size, volume, density, specific gravity, surface area, and other chemical and microbiological characteristics that might be used as designing parameters for food production. By using these procedures, it is possible to calculate these characteristics and subsequently obtain information on the impacts of processing. Determining the physical and chemical characteristics of the red and yellow date seed variants is the main objective of this

research. To this end, the research's specific goals include analysing the physical traits of these red and yellow date seed varieties, assessing their nutritional and bioactive qualities, and looking into their antimicrobial qualities, which include antibacterial and antifungal qualities.

Throughout history, fruits are a staple in human diets, serving religious, nutritional, and cultural purposes. In the US, fruits and vegetables gained recognition as exceptionally healthy, as shown by the 1998 USDA survey (USDA, 1999). For millennia, date palms provided sustenance, materials, and thrived in challenging environments (Johnson *et al.*, 2002; Johnson, 2010). There are three main stages of date fruit ripening: khalal, rutab, and tamar. After pollination, date palm fruit undergoes five stages of maturation that are distinguished by variations in taste, colour, texture, and chemistry (Baliga *et al.*, 2011). During the rainy season, date palm fruits are harvested at the khalal and Rutab ripening stages. These fruits, often consumed fresh, suffer significant losses due to fungal and microbial deterioration, resulting in low market prices (Al shaikley, 1996). Much of the date fruit processing still relies on traditional methods. Therefore, characterising the fruits to understand their engineering properties becomes crucial. Acquiring fundamental information about these properties is highly valuable

for engineers, food scientists, and processors. This knowledge aids in developing efficient processes, equipment, and strategies for the handling, processing, and storage of date fruits.

**Materials and Methods**

**Sample Collection and preparation**

The experimental procedures were carried out at the Crop Processing Laboratory, Department of Agricultural and Environmental Engineering, Federal

University of Technology, Akure, Nigeria, which is situated at latitude 5°08'53'E and longitude 7°17'38'N, to investigate the engineering properties of date fruit seeds. The yellow and red varieties of date palm fruit (*Phoenix dactylifera L.*) in the Tamar stage (full maturity) were procured from a local market in Kaduna state, Nigeria. About 250 date samples were collected and stored in the refrigerator. The seeds, were separated from the date pulps (Figure 1). Care was taken to select fruit samples devoid of dirt and other extraneous substances.

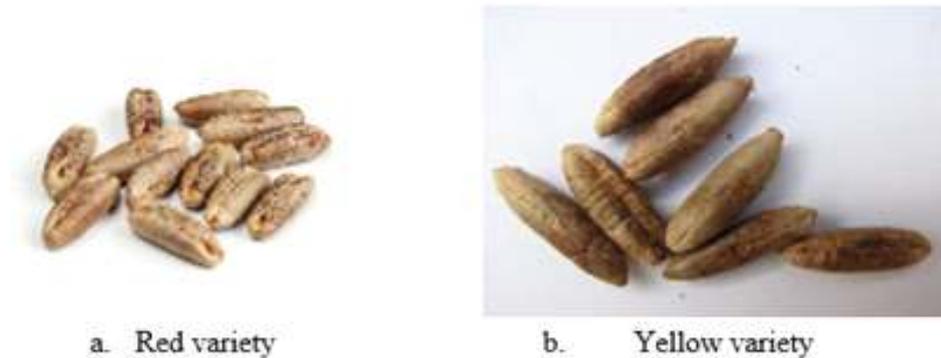


Figure 1: Date fruit seeds

**Physical Properties**

For the practical, the equipment utilized included: a digital weighing scale (Ohaus CS-Series), desiccators, measuring cylinders, and a tray. The physical properties of the date seeds were assessed through three primary dimensions: length (L), width (W), and thickness (T), using vernier calliper.

**a. Mass Determination**

Soyoye et al. (2018) proposed utilizing an electronic weighing balance with a maximum capacity of 500g and a sensitivity of 0.01g to calculate the mass of each individual seed.

**b. Volume Determination**

Seed volumes were measured using the water displacement method. Seeds were weighed and allowed to float in water. Fruits were lowered with a needle into a graduated beaker containing water and the mass of water displaced by the individual fruit was recorded. Finally, fruit densities (g/cm<sup>3</sup>) were calculated by using Equation (1) (Mohsenin, 1986)

$$\pi B_g^2(2L - B) \tag{1}$$

**a. Bulk Density**

The bulk density was determined using the mass/volume relationship stated in Equation 2 (Owolarafe et al., 2007) by filling an empty plastic container of predetermined volume and mass with the fruits were poured from a constant height, and weighed.

$$\rho_b = \frac{m}{v} \tag{2}$$

where  $\rho_b$  is the bulk density (g/cm<sup>3</sup>), m and v are bulk mass of fruit (g), and the plastic container volume (cm<sup>3</sup>), respectively.

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

$$D_g = (L \times W \times T)^{1/3} \tag{4}$$

where: L is length (mm), W is width (mm), and T is thickness (mm)

**a. Surface Area Determination**

The surface area in mm<sup>2</sup> is determined as recommended by Mohsenin (1986), using Equation 5. Where: S is surface area, mm<sup>2</sup>; D<sub>g</sub> is geometric mean diameter.

$$S = \pi D_g^2 \tag{5}$$

**a. Sphericity (Φ) determination**

Sphericity was determined using the Equation 6.

$$\Phi = \frac{(LWT)^{1/3}}{L} \tag{6}$$

$$\frac{\text{lossed weight of date seed}}{\text{initial weight of sample taken}} \times 100 \tag{7}$$

**a. Carbohydrate Determination**

The carbohydrate content was calculated using Equation 8 (Olabinjo, 2020).

$$\text{carbohydrate}(\%) = 100 - [\text{protein}(\%) + \text{Moisture}(\%) + \text{Ash}(\%) + \text{Fibre}(\%) + \text{CrudeFat}(\%)] \dots\dots\dots(8)$$

**a. Evaluation of antibacterial activities of the samples**

Agar well diffusion method modified by Daoud *et al.* (2019) was employed for the experiment. Isolation of each bacterium were seeded on MHA plates for about 30 minutes, sterile cup bores of 10mm diameter were used to make wells, solidified into which were filled with 0.5ml of the extract concentration 0.05g/ml of distilled water and allow it diffuse for 45minutes. The plates were incubated at 37°C for 24 hours. Zones of incubation around the well were measured with digital vernier callipers, results were quoted as the mdii (mno) of the zone incubation, around the well, and positive control plates were avoided using ciprofloxacin (500mg) as standard.

The bacteria strains used for this virus experiment were cultured aerobically at 37°C for 24 hours and peptone water and antibacterial testing were carried out on Mueller Hinton Agar (MHA). The bacteria strains are *X. axonopodis* pv. *Phaseoli*, *Salmonellae*, *Enterococcus faecalis* and *Erwinia carotovora*.

**Statistical Analysis**

The following descriptive statistics namely: maximum, minimum, average, standard deviation were obtained using Microsoft Excel 2016.

**Results and Discussion**

**Physical Properties**

Table 1 shows a comprehensive summary on the physical characteristics and dimensions of yellow date seeds, derived from a dataset of 200 observations. This dataset revealed the physical characteristics of the date seeds. With an average mass of 1.93 grams and a standard deviation of 0.31 grams, the mass of these seeds specifically varies from a minimum of 0.85 grams to a maximum of 3.01 grams. Length measurements range from 20.85 mm to 43.40 mm, with an average of 32.13 mm and a standard deviation of 4.39 mm. Similarly, the breadth measurements vary, with an average of 10.5 mm and a standard variation of 1.19 mm, and a range of 7.25 mm to 14.00 mm. The date seeds exhibit differences in thickness as well, with an average of 8.20 mm and a standard deviation of 1.25 mm. The thickness ranges from 5.40 mm to 11.00 mm. In terms of volume, date seeds have a range of 0.30 ml to 2.40 ml, with an average of 1.40 ml and a standard deviation of 0.33 ml. The Arithmetic Mean Diameter (AMD) varies from 12.95 mm to 19.61 mm, with an average AMD of 16.30 mm and a standard deviation of 1.12 mm. In addition, the Geometric Mean Diameter (GMD) extends from 10.91 mm to 16.27 mm, with an average GMD of 13.59 mm and a standard deviation of 0.86 mm. The date seeds have a surface area that is within the range of 378.00 and 832.00 mm<sup>2</sup>, with an average of 605.00 mm<sup>2</sup> and a standard deviation of 70.00 mm<sup>2</sup>. In addition, sphericity values ranged from 0.29% to 0.68% with an average of 0.34% and a standard deviation of 0.08%. Lastly, bulk density measurements showed an average bulk density of 0.63 g/cm<sup>3</sup> and a standard deviation of 0.06 g/cm<sup>3</sup>, ranging from 1.00 g/cm<sup>3</sup> to 1.26 g/cm<sup>3</sup>.

**Table 1: Physical Measurements of Date Seeds (Yellow Variety)**

Properties of date seed	Number of observations	Minimum value	Maximum value	Mean value	Standard deviation
Mass, g	200	0.85	3.01	1.93	0.31
Length (L), mm	200	20.85	43.40	32.13	4.39
Width (W), mm	200	7.25	14.00	10.5	1.19
Thickness mm	200	5.40	11.00	8.20	1.25
Volume, ml	200	0.30	2.40	1.40	0.33
GMD (mm)	200	10.91	16.27	13.59	0.86
AMD (mm)	200	12.95	19.61	16.30	1.12
Surface area, mm <sup>2</sup>	200	378.00	832.00	605.00	70.00
Sphericity, %	200	0.29	0.68	0.34	0.08
Bulk density, g/cm	200	1.00	1.26	0.63	0.06

Table 2 presents a summary of the physical characteristics and dimensions of date seeds, utilizing a dataset with 40 observations. The mass of these date seeds spans from a minimum of 0.99 grams to a maximum of 1.76 grams, with an average mass of approximately 1.40 grams and a relatively low standard deviation of 0.20 grams, indicating a limited degree of variability in mass. Similarly, the length measurements fall within the range of 21.40 mm to 25.75 mm, with an average length of 23.60 mm and a standard deviation of 1.30 mm, suggesting consistent measurements around the mean. The width dimensions ranged between 9.00 mm and 14.30 mm, with an average width of 12.01 mm and a standard deviation of 0.86 mm, again showing relatively low variability. The thickness data revealed a minimum and maximum values of 6.65 mm and 9.15 mm respectively, with an average thickness of 8.00 mm and a standard deviation of 0.58 mm, indicating consistency around the mean value. Volume measurements also demonstrate this trend, with a range of 0.60 ml to 1.80 ml, an average volume of 1.20 ml,

and a standard deviation of 0.26 ml, suggesting measurements closely clustered around the mean. The Geometric Mean Diameter (GMD) falls between 10.80 mm and 13.52 mm, with an average GMD of 12.16 mm and a standard deviation of 0.64 mm, indicating moderate variability. Similarly, the Arithmetic Mean Diameter (AMD) exhibits variability ranging from 12.88 mm to 15.28 mm, with an average AMD of 14.08 mm and a standard deviation of 0.70 mm. The surface area measurements span from 366.00 mm<sup>2</sup> to 574.00 mm<sup>2</sup>, with an average surface area of 470.00 mm<sup>2</sup> and a standard deviation of 49.00 mm<sup>2</sup>, indicating some variability in the data, though the measurements are clustered around the mean. Sphericity values range from 0.48% to 0.58%, with an average sphericity of 0.53% and a standard deviation of 0.02%, revealing highly consistent values. Finally, bulk density measurements show variation from 0.94 g/cm<sup>3</sup> to 1.06 g/cm<sup>3</sup>, with an average bulk density of 0.50 g/cm<sup>3</sup> and a standard deviation of 0.05 g/cm<sup>3</sup>, indicating relatively low variability in bulk density.

**Table 2: Physical measurements of date seeds (Red variety)**

Properties of date seed	Number of observations	Minimum value	Maximum value	Mean value	Standard deviation
Mass, g	40	0.99	1.76	1.40	0.20
Length (L), mm	40	21.40	25.75	23.60	1.30
Width (W), mm	40	9.00	14.30	12.01	0.86
Thickness, mm	40	6.65	9.15	8.00	0.58
Volume, ml	40	0.60	1.80	1.20	0.26
GMD (mm)	40	10.80	13.52	12.16	0.64
AMD (mm)	40	12.88	15.28	14.08	0.70
Surface area, mm <sup>2</sup>	40	366.00	574.00	470.00	49.00
Sphericity, %	40	0.48	0.58	0.53	0.02
Bulk density, g/cm	40	0.94	1.06	0.50	0.05

**Chemical Properties**

Tables 3 summarizes the findings of the study's investigation of the nutritional qualities and total phenolic content, for the two varieties of date seeds (Yellow and Red).

**a. Ash Content**

The ash content results for the red (1.05%) and yellow (1.08%) varieties in this study were lower than those found in samples (3.27%) studied by Ogungbenle, (2011) and in kimri (1.6%) as reported by Gamal *et al.* (2012). This finding aligns with results from the analysis of different date palm fruit varieties (1.3% for Dora, 1.7% for Dhaki, and 1.5% for Karbaline) reported by Anjum *et al.* (2012). The lower ash content suggests a lower mineral deposit in the samples compared to the values recommended by the FAO. This implies that date palm fruit likely contains high-quality essential minerals.

**b. Moisture Content**

The findings indicate that the moisture content in the yellow variety (5.76%) is higher than that in the red variety (4.87%). The moisture content of the red date variety is lower than that of the Zedhi variety (5.24%), as reported by Ogungbenle, (2011). Anjum *et al.* (2012) reported the moisture content of different varieties of date palm seeds as 7.81% for Dora, 9.90% for Dhaki, and 6.3% for Karbaline, respectively. These variations may be attributed to factors such as location, time, environmental conditions, longevity, and maturity of the samples used for analysis. The low moisture content observed in the sample suggests that this specimen may be less prone to decay, as foods with high moisture content are more susceptible to spoilage.

**c. Crude Fat Content**

The results presented in this study exceeded those reported by El-Rahman, (2017) who found that date

seeds contained high levels of crude oil, which were 5.95 and 6.4 times higher than those in date fruits and palm shells, respectively. This percentage favors the extraction of seed oil, which offers numerous benefits. The study of two Tunisian cultivars by Besbes *et al.* (2009) indicated that date seed oils contain high relative percentages of oleic acid. They also have a more yellow color than other vegetable oils and can provide protection against UV light, which is responsible for much cellular damage. Date seed oils can be easily preserved due to their high oxidative stability. Given these characteristics, the value of this by-product in the cosmetic and food industries seems justified. However, the antioxidant composition of date seed oil must be tested to further enhance the value of this by-product.

**d. Crude fibre content**

The crude fiber content of the red (12.3%) and yellow (13.2%) varieties, as shown in Table 3, is lower than the 16.4% reported by Gamal *et al.* (2012). However, they are similar to the 13.4% reported for the Zedhi variety by Ogungbenle, (2011). Dietary fiber serves as a valuable tool in controlling oxidative processes in food products and as a functional food ingredient (Mandalari *et al.*, 2010). Crude fiber reduces the absorption of cholesterol from the gut and also delays the digestion and conversion of starch into simple sugars, which is an important factor in the management of diabetes (Cust *et al.*, 2009).

**e. Protein content**

The obtained result indicates that the red date seeds contain a higher protein content compared to the yellow

date seeds variety. The protein content of the red date seeds was similar to that of the Saudi date variety (3.12%), as reported by El-Rahman and Al-Mulhemi, (2017).

**f. Carbohydrate content**

The results in Table 3 indicate that the yellow date seeds (61.02%) had a higher carbohydrate content than the red variety (60.6%). This value is lower than the 80.67% reported for the Dhaki variety by Ogungbenle, (2011). The total sugar content has been observed to increase from 3.4% to 7.7% in the Kimri stage and from 43.40% to 87.54% in the Tamar stage (Al-Shahib and Marshall, 2003; Manickavasagan *et al.*, 2012).

**g. Total Polyphenols Content**

Significant variation in total phenolic contents was evident among the studied varieties, with the red variety boasting the highest total phenolic content of 31.4 mg/g, closely followed by the yellow variety of 31.2 mg/g. Phenolics exhibit notable antioxidant properties, functioning as effective scavengers of free radicals. Numerous research groups, including Benmeddour *et al.* (2013) and El Sohaimy *et al.* (2015), have emphasized the phenolic acid richness of dates. Comparatively, date pulp reported a content of 2.5 mg/100 g according to El-Rahman and Al-Mulhemi (2017), underlining seeds as a prolific source of phenolic compounds. Due to their high phenolic content, seeds hold potential applications in functional foods, food additives, pharmaceuticals, and the cosmetic industry, as highlighted by Wali and Guizani, (2016).

**Table 3: Nutritional Composition of the red and yellow date seeds**

Variety	MC	Ash	CF	Fat	Protein	CHO	TPC (mg/g)
Red	4.87	1.05	12.30	18.02	3.12	60.63	31.41
Yellow	5.77	1.09	13.27	17.48	1.38	61.02	31.28

MC moisture content, CF Crude fibre, CHO carbohydrate, TPC total phenolic content

**a. Antibacterial Activities**

The study recorded antimicrobial responses against five pathogenic bacteria, specifically *X. axonopodis* pv. *Phaseoli*, *Salmonellae Typhinurium*, *Enterococcus faecalis*, and *Erwinia carotovora*. The Ethanoic and Ethyl-Acetate extracts demonstrated robust antibacterial efficacy against *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermis*, and *Salmonella Typhinurium*. Conversely, the hot

water extract exhibited minimal impact on all tested bacterial species (Figure 4). Impressively, ethanol extracts from date seeds displayed the highest effectiveness against all bacteria under examination, aligning with earlier findings by Saleh and Otaibi, (2013). The antibacterial activity observed in date extracts could stem from phenolic compounds, which are more efficiently extracted through ethanol and ethyl-acetate rather than water. The experiment was conducted in triplicate to ensure robustness and reliability of the results.

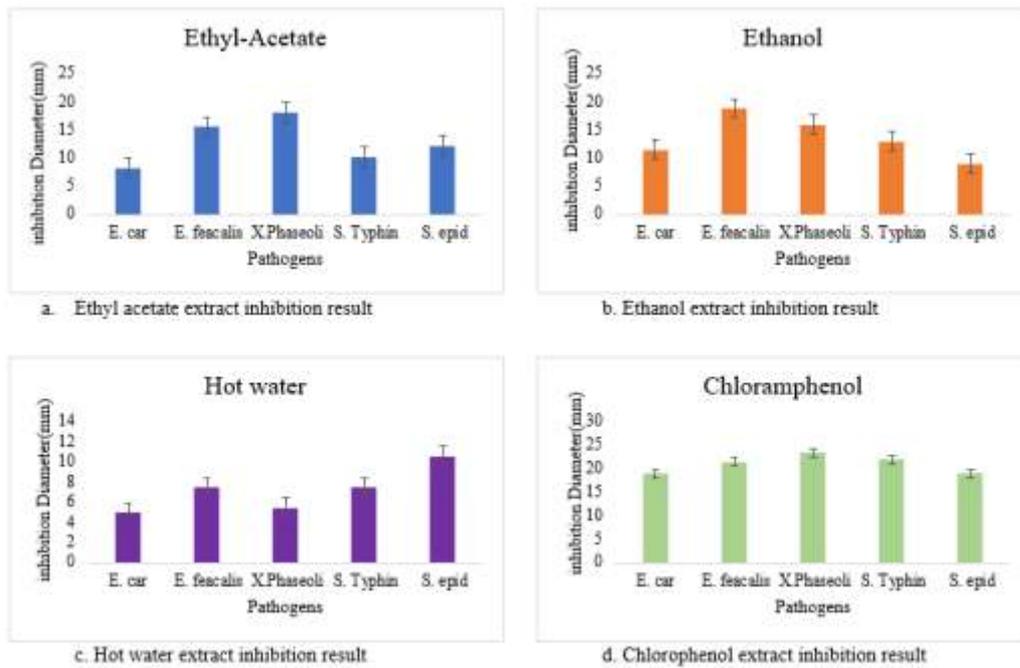


Figure 4: Antibacterial Activities of the Sample (after 24 hours of incubation, at 37°)

### Conclusion

The study provided insights into the physical, chemical, and microbial composition of two date varieties. It revealed significant differences between the investigated date varieties across various parameters. The physical characteristics analysis focused on properties like mass, length, width, thickness, arithmetic mean diameter, and geometric mean diameter. The yellow variety displayed broader ranges and higher values for axial dimensions and weight-related parameters compared to the red variety. Engineering properties were also influenced by the varietal differences, which could impact post-harvest technology and fruit processing equipment design. The chemical analysis indicated that the yellow date seed variety had a more substantial nutritional composition than the red variety. Date seeds emerged as an excellent source of protein, crude fibre, and oil for food ingredients. Moreover, the study's microbial analysis suggested that ethanol extracts from dates could potentially serve as natural food preservatives and a source of health-protective compounds with antimicrobial activity.

### References

Al shaickley, E.B. (1996). Chemical composition of date varieties as influenced by the stage of ripening. *Food Chemistry*, 54, 305-309

Al-Shahib, W. and Marshall, R.J. (2003). The fruit of the date palm: its possible use as the best food for the future. *International Journal of Food Science and Nutrition*, 54, 247-259.

Anjum, F. M., Bukhat, S. I., El-Ghorab, A. H., Khan, M. I., Nadeem, M., Hussain, S., and Arshad,

M. S. (2012). Phytochemical characteristics of date palm (*Phoenix dactylifera*) fruit extracts. *Pakistan Journal of Food Science*, 22(3), 117-27.

AOAC (Association of Official Analytical Chemists) (2006). *Official Methods of Analysis*, 15th Ed. (Gaithersburg, S. edn). AOAC Press, Washington DC., USA. p. 78-90.

Baliga, S.M., Baliga, B.R.R., Kandathil, S.M, Harshith, P.B. and Kumar, V. (2011). A review of the chemistry and pharmacology of the date fruits (*Phoenix dactylifera* L.) *Food Research International* 44, (7), 1812-1822.

Benmeddour Z., Mehinagic E., Le Meurlay D. and Louaileche H. (2013). Phenolic composition and antioxidant capacities of ten Algerian date (*Phoenix dactylifera* L.) cultivars: a comparative study. *Journal of Functional Food*, 5, 346-354.

Besbes, S., Drira, L., Blecker, C., Deroanne, C. and Attia, H. (2009). Adding value to hard date (*Phoenix dactylifera* L.): compositional, functional and sensory characteristics of date jam. *Food chemistry*, 112, 406-411.

Cust A. E, Skilton M. R. and Van B.M.M.E. (2009). Total dietary carbohydrate, sugar, starch and fibre intakes in the European Prospective Investigation into cancer and nutrition. *European Journal of Clinical Nutritional*, 63, 37-60.

Daoud, A., Malika, D., Bakari, S., Hfaiedh, N., Mnafigui, K., Kadri, A., and Gharsallah, N., (2019). Assessment of polyphenol composition, antioxidant and antimicrobial

- properties of various extracts of Date Palm Pollen (DPP) from two Tunisian cultivars. *Arabian Journal of Chemistry*, 12(8) 3075-3086
- El Sohaimy, S., Abdelwahab, A., Brennan, C. and Aboul-enein, A. (2015). Phenolic content, antioxidant and antimicrobial activities of Egyptian date palm (*Phoenix dactylifera* L.) fruits. *Australian Journal of Basic Applied Science*, 9, 141-147.
- El-Rahman, S. N. A., and Al-Mulhem, S. I. (2017). Characteristic analysis, antioxidant components and antioxidant activity of date fruits, date seeds and palm shell. *Journal of Clinical Medical Case Report*, 1(1), 1-5.
- Food, Nutrition and Health. (2020). Biotechnology and Biological Sciences Research Council. Retrieved May 23, 2020 from [bbsrc.ukri.org](http://bbsrc.ukri.org)
- Gamal, A. E., Salah, M. A. and Mutlaq, M. A. (2012). Nutritional Quality of Biscuit Supplemented with Wheat Bran and Date Palm Fruits (*Phoenix dactylifera* L.). *Food and Nutrition Science*, 3, 322-328.
- Johnson, D. V. (2010, March). Worldwide dispersal of the date palm from its homeland. In *IV International Date Palm Conference* 882 (p. 369-375).
- Johnson, D. V., Joyal, E. and Harris, R. K (2002). Date palm varieties in Arizona. *Fruit Garden*. 34 (5):6-9.
- Juhaimi, F. A., Ghafoor, K. and Özcan, M. M. (2012). Physical and chemical properties, antioxidant activity, total phenol and mineral profile of seeds of seven different date fruit (*Phoenix dactylifera* L.) varieties. *International Journal of food sciences and nutrition*, 63(1), 84-89.
- Mandalari, G., Tomaino, A., Arcoraci, T., Martorana, M., Turco, V.L., Cacciola, F., Rich, G.T., Bisignano, C., Saija, A., Dugo, P., Cross, K.L., Parker, M.L., Waldron, K.W., Wickham, M.S.J. (2010). Characterization of polyphenols, lipids and dietary fibre from almond skins (*Amygdalus communis* L.). *Journal of Food Composition and Analysis*. 23(2), 166-174.
- Manickavasagan, A., Mohamed, E.M. and Sukumar, E. (2012). Dates: Production, Processing, Food, and Medicinal Values (Medicinal and Aromatic Plants – Industrial Profiles) CRC Press, Boca Raton, Florida.
- Mohsenin, N. N. (1986). *Physical properties of plants and animal materials*. Gordon Breach Science Publishers. *International Commission of Agricultural and Biosystems Engineering Journal*, 20, 18-89.
- Ogungbenle, H.N. (2011). Chemical and fatty acid compositions of date palm fruit (*Phoenix dactylifera* L.) Flour. *Bang. Journal of Scientific and Industrial Research (JSIR)*. 46(2), 255-258.
- Olabinjo, O. O., (2020). Evaluating the nutritive and effect of varying temperatures on quality attributes of monkey cola (*cola millenii*) seeds. *Annals. Food Science and Technology*, 21 (1), 355-363.
- Owolarafe, O.K., Olabigeand, T.M. and Faborode, M.O. (2007). Macro-structural characterization of palm fruit at different processing conditions. *Journal of Food Engineering*, 78, 1228-1232.
- Saleh, F.A. and Otaibi, M.M. (2013). Antibacterial Activity of Date Palm (*Phoenix Dactylifera* L.) Fruit at Different Ripening Stages. *Journal of Food Processing Technology* 4, (285), 1-6.
- Shen, X., Sun, X., Xie, Q., Liu, H., Zhao, Y., Pan, Y., and Wu, V. C. (2014). Antimicrobial effect of blueberry (*Vaccinium corymbosum* L.) extracts against the growth of *Listeria monocytogenes* and *Salmonella Enteritidis*. *Food control*, 35(1), 159-165.
- Soyoye, B.O., Ademosun, O.C., and Agbetoye, L.A.S (2018). Determination of some physical and mechanical properties of soybean and maize in relation to planter design. *Agricultural Engineering International: CIGR Journal* 20.18-89.
- Tarighi, J., Mahmoudi, A. and Alavi, N. (2011). Some mechanical and physical properties of corn seed (Var. DCC 370). *African Journal of Agricultural Research*, 6 (16), 3691-3699.
- United States Department of Agriculture (1999). *Agricultural Resources Management Survey (ASMR) Phase III – Interviewer's Manual*. National Agricultural Statistics Service.
- Waly, M. I., and Guizani, N. (2016). Health aspects of antioxidant nutrients: a concise update. *Journal of Agricultural Research*, 1(1), 1-6.