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Nutrients depictions of Barhi date palm (*Phoenix dactylifera* L.) kernels

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Abstract

Phoenix dactylifera L (Date palm) is one of the oldest known fruit crops in the world, and the consumption of date fruits is no longer restricted to the Middle Eastern countries. Date palm kernels are waste products of date fruit industry which are normally being discarded. Based on their dietary fiber content; date palm kernels (DPK) have been proposed to be used as fiber-based food supplement, caffeine free coffee alternative and animal feed ingredient. Hence, utilization of such waste is highly desirable for the date industry. To accommodate these benefits, and subsequent to some uses associated with DPK, this study sought to investigate the biochemical and nutritional values of the Barhi date palm kernels (BDPK) grown in Iraq. The results show that BDPK is an excellent source of dietary fiber (66.24 g/100g). Glutamic acid was found to be the predominant amino acid, (0.674 g/100g), followed by Arginine and aspartic acid (0.437 g/100g and 0.320 g/100g, respectively). Potassium was the most occurring mineral in BDPK (2.39 g/kg), and the main sugars were sucrose and fructose (0.548 g/100g and 0.249 g/100g, respectively). Gas-liquid chromatography revealed that the main unsaturated fatty acid (USFA) was oleic acid (40.927 mg/100g), while the main saturated fatty acid (SFA) were lauric acid (20.270 mg/100g) and myristic acid (12.288 mg/100g). Furthermore, the BDPK depicted considerable concentrations of vitamins, in which vitamin B5 (40.4 mg/100g) showed the highest value. The results obtained indicate a strong potential for BDPK to be used in human nutrition, cosmetics, and pharmaceutical applications and may provide an important economic advantage through increasing the utilization of BDKP while also additive value will be added to the residue.

Introduction

Date palms (*Phoenix dactylifera* L. family Arecaceae) are plants of enormous nutritional, medicinal and economic values. They are one of the most important crops in arid and semiarid regions of the world, mainly in the Arabian Peninsula, Middle East and North Africa (Al-Farsi et al., 2005). In Iraq, there are 370 different types of dates (Simozrag *et al*., 2016), in which Barhi date is one of the most important date cultivars (cvs) (Al-Bakr, 1972). In 2012, cumulative world date fruit production amounted to 7,548,918 metric tonnes (mt), in which Iraq alone produced 650,000 mt of date fruit and was ranked among the top five world producers of date fruit according to FAOSTAT (Al-Khayri *et al.*, 2015). Top five date fruit production by country in 2012, in mt, presented here in descending order: Egypt (1,470,000), Iran (1,066,000), Saudi Arabia (1,050,000), Algeria (789,357) and Iraq (650,000), in which Medjool, Deglet Noor, Ajwa, and Barhi cvs are on the top of the international market and have already marketed with higher prices due to their unique qualities (Al-Khayri *et al*., 2015).

The date fruit is composed of fleshy pericarp and kernel (pit), in which kernel constitutes approximately 10% of date fruit weight (Almana and Mahmoud, 1994). With world production of dates reaching 7.5 million tonnes, approximately 750 thousand tonnes of kernels are produced (Tilman *et al*., 2011; Al-Khayri *et al*., 2015), which are usually discarded after consuming the pulp of date fruits as well as during date processing industries and after technological transformations hence creating a “waste”, which can create potential negative effects on environment (Angulo *et al*., 2012), while also losing a potential important nutritional part of the fruit itself that could serve as a potential extractable value-added materials to be used on an industrial scale; in the cosmetic, pharmaceutical and/or food industries (Al-Farsi *et*

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al., 2007; Ahmed *et al*., 2013; O'Shea and Plenge, 2012). DPK have been overlooked due to being directly inedible. The hard coated DPK, usually oblong, ventrally grooved, with a small embryo, and with a hard endosperm made of a cellulose deposit on the inside of the cell walls, are adapted to withstand harsh environmental conditions (Zaid and Arias-Jimenez, 2002). So, DPK must be ground into fine powder to be consumed.

Most of the previous studies on the nutritional composition and functional values focused on the flesh of date palm (Hussein and El Zeid, 1975; Auda *et al*., 1976; Al-Hooti *et al*., 1998; Al-Shahib and Marshall, 2003; Gehring *et al*., 2011; Osman, 2015) whereas only few studies have studied the chemical composition of the DPK (Alshowiman and BaOsman, 1992).

To best of our knowledge, limited data is available regarding the nutritional characteristics of Barhi date palm kernels (BDPK) grown in Iraq, and since a lot of kernels are being produced as a waste, this study is conducted to measure the nutritive value of the most valuable Iraqi date palm variety (Barhi). Detailed measurement of nutritional composition and health-promoting components of BDPK will enhance our knowledge and appreciation for the use of BDPK in many sectors such as functional foods and ingredients in nutraceuticals, pharmaceuticals, and medicine.

Materials and methods

Preparation of the BDPK

Barhi date fruit was purchased from the King of Dates market in Karrada-Dakhil, Baghdad, Iraq. The Barhi date palm kernels (BDPK) were collected at the "tamr stage" (full ripeness). BDPK were manually separated from the flesh rip fruit and soaked in water, washed to free them of any adhering date flesh, air-dried carefully under shade at room temperature. The dried BDPK were oven dried for two days at 45°C and then finely ground into powder (1 mm) in a hammer mill to generate a homogenous powder.

Chemical analysis of powdered BDPK

Ash content was determined according to the Association of Official Analytical Chemists (AOAC) (Longvah and Deosthale, 1998). It was determined after incineration of powdered BDPK at 550°C, during 8 h, using a muffle furnace (NABER, Germany). It was expressed as percent of dry weight.

Protein content

Total protein was determined by the Kjeldahl method. The determination of total nitrogen (N) was carried out as described by AOAC (Helrich, 1990), which involves the transformation of organic N to ammonium (NH_4^+) with concentrated sulfuric acid (H_2SO_4) to digest the sample and then measuring the amount of NH_4^+ produced.

Fat content

Lipid extraction was measured with an SER 148 Solvent Extractor (Velp Scientifica, Milan, Italy) equipped with six Soxhlet posts. The extraction process was carried over a 30 minutes (min) period, with thimbles immersed in boiling petroleum ether and 60 min of reflux washing. The solvents from seed oils were removed by distillation. Then, the residue was dried at 103°C and stored in a freezer (−20°C) until analyzed.

Fatty acid analysis

After the extraction of oil from BDPK, it was converted to their methyl esters through using the standard boron trifluoride methanol method, which were essentially completely esterified in about two minutes. The esters were easily recovered and then analysed by gas chromatograph. The boron trifluoride–methanol (BF3–MeOH) method, in brief, is of two stages; (1) saponification in methanolic NaOH for 5–10 min; (2) Addition of BF3–MeOH reagent (12–15%) to soaps in situ and boil for 2-3 min (Moss *et al*., 1974). The consequential mixture of fatty acid methyl esters was injected into a Varian 3900 gas chromatograph, which was equipped with flame ionization detector (FID), capillary column (50 m × 0.25 mm) WCOT Fused Silica (CP-Sil 88 for FAME) at a column temperature of 190°C, whereas the injector's temperature was 270°C, and the detector's temperature was 300°C. Fatty acids separations were carried out with Hydrogen carrier gas. A small amount of methyl ester solution (1 µL) was introduced into the column. Identification of peaks was based on retention times and quantified according to the peak areas of the standard fatty acid methyl esters at 10 mg/mL. All measurements were performed in duplicate and the mean values were reported (Habib *et al*., 2013).

Mineral analysis

100 ppm stock solutions of minerals were prepared by dissolving required amount of their salts in distilled water for elemental analysis of the sample (Adeosun *et al*., 2016). The sample was digested according to the perchloric acid digestion method (Allen, 1984). A quantity (0.25 g) of the sample was taken into a 50-mL flask; 6.5 mL of mixed acids solution contain nitric acid, sulfuric acid,

perchloric acid in ratio 5:1:0.1 was added and boiled on a hot plate in a fume hood until the digestion was completed. The digestion process was completed when white fumes rise from the flasks. The digested sample was allowed to cool down naturally and is then transferred into a 50-mL volumetric flask by raising the volume of distilled water. After that, the digested sample was filtered through Whatman filter paper (No. 42). The filtrate which consists of the interested elemental concentrations in the sample was determined using Shimadzu AA-670 Atomic Absorption Spectrophotometer.

Amino acids content

Amino acids of BDPK (150 mg) were analyzed according to the method of Bouaziz (Bouaziz *et al*., 2008) by a BioChrom 20 plus amino acid analyzer after hydrolyzed with HCl (6N) at 110°C for 24 h. Amino acids were analyzed by chromatographic ionic exchange and identified colorimetrically using Ninhydrin reagent. Proline and hydroxyproline were detected at 440 nm, whereas the other amino acids were detected at 570 nm, whereas. The concentrations of amino acids were calculated from the standard curves.

Dietary fiber

Dietary fiber was determined using the AOAC enzymatic-gravimetric official method (Method 991.43, AOAC, 2003; Chau and Huang, 2003).

Carbohydrate content

Carbohydrate content was estimated by the difference of mean values: 100 - (sum of percentages of ash, moisture, protein, lipids and dietary fiber) (Al-Hooti *et al*., 1998; Besbes *et al*., 2004).

Vitamin analysis

Water-soluble vitamins and fat-soluble vitamins were determined using a reversed-phase high-performance liquid chromatographic procedure according to Moreno and Salvadó, 2000).

Results and discussion

Proximate analysis of BDPK

Dietary fibre (DF)

The results of the proximate analysis of BDPK are presented in Table 1. The reported composition was 5.29% protein, 8.69% fat, 0.86% ash and 66.24% dietary fibre (DF). This is similar to the nutritional properties of date palm kernels (DPK) reported by Al-Farsi and co-workers (Al-Farsi *et al*., 2007), who found that the proximate composition of Omani date kernels were 2.3–6.4% protein, 5.0–13.2 fat, 0.9–1.8% ash and 22.5–80.2% dietary fibre. DF was the predominant component in BDPK, followed by moisture (10.36%), along with small amounts of fat, carbohydrate, protein and ash (Table 1). Ash contents cannot be neglected as they identify the existence of inorganic compounds (minerals) in form of salts and oxides in food (Khalid *et al*., 2016). Moisture content is also an important indicator of the shelf life of food items. Based on the results on moisture content, BDPK can be stored for long time and will be less susceptible to microbial spoilage and enzymatic reactions (Swayat *et al*., 1983)

Table 1. Proximate analysis and dietary fiber composition of Barhi date palm kernels (BDPK)

Component	g/100g
Moisture	10.36 ± 0.015
Protein	05.29 ± 0.100
Fat	08.69 ± 0.180
Ash	0.86 ± 0.050
Dietary fiber	66.24 ± 0.000
Crude fiber	67.38 ± 0.830
Carbohydrate	08.56 ± 0.069
Fructose	0.249 ± 0.050
Glucose	0.199 ± 0.000
Sucrose	0.548 ± 0.050
Maltose	ND (<0.001)

Values are mean of two replicates ± standard deviation (SD).
ND: Not detected (Below detection limit)

BDPK contains 67.38% crude fibre (Table 1). Crude fibre in DPK can be defined as the insoluble part of dietary fibre that includes compounds like cellulose, hemicellulose, lignin, lignocellulose, and insoluble proteins (Barreveld, 1993; Biglari, 2009). Crude fibre content however, is not a true indication of its total dietary fibre content (Yousif *et al*., 1982) since it may contain also pectin, gums, mucilages and starch (Ashraf and Hamidi-Esfahani, 2011). Whereas dietary fibre (DF), according to the American Association of Cereal Chemists, is defined as the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine. DF includes insoluble and soluble fibre (Rodriguez *et al*., 2006).

According to well-documented studies conducted on the physicochemical properties of DF extracted from date flesh, the DF concentrates showed some functional properties in the food industry such as high water-holding capacity, high oil-holding capacity, emulsifying, pseudoplasticity behaviour of their suspensions, and gel formation. DF can be used as an ingredient in food products like dairy, soup, meat, bakery products and jam to modify textural properties, avoid syneresis, and stabilise high fat food and emulsions (Elleuch *et al*., 2008; Ashraf and Hamidi-Esfahani, 2011).

Moreover, alimentary importance of crude and dietary fibres has received considerable attention of researchers towards significant role in the prevention of several diseases such as obesity, diabetes, hypertension and hyperlipidemia (Kris-etherton *et al.*, 2002), and has been related to a decreased incidence of several types of cancer (Beecher, 1999). Dates are renowned for higher level of crude fibres, soluble, insoluble and total dietary fibres in kernels and flesh but there is always some variation due to variable content of moisture and genetic variability among cultivars. Regarding food carbohydrates, it has been proved that DF can affect their bioavailability in the intestinal tract. This effect has been confirmed in diabetic patients, whose levels of glucose in blood decreased by having diets rich in fibre. Higher level of crude fibre and DF contents in BDPK found in this study make it suitable for incorporation in dietary supplement (Habib and Ibrahim, 2009; Khalid *et al*., 2016).

Palm date and its fibres have several nutritional values such as antioxidant activity (Al-Farsi *et al*., 2007; Amorós *et al*., 2009). The antioxidant activity could be attributed to its lignin content, as lignin has been reported to have antioxidant and antimicrobial activities (Kamm *et al*., 2007; Khalid *et al*., 2016).

Habib and Ibrahim (2009) studied the dietary fibre contents in DPK from different date varieties and found that the contents ranged from 67% to 74% of fresh weight DPK powder. Al-Farsi and Lee (2008) reported greater amounts (77% to 80% fresh weight) than those reported by Habib and Ibrahim (2009). The high nutritional value of BDPK is therefore based on their dietary fibre content, which makes them appropriate for the preparation of fibre-based foods like bread, biscuits, and cakes and dietary supplements. DF from BDPK could also be used as an alternative to wheat bran, and it may contribute to daily dietary fiber intake (Almana and Mahmoud, 1994). Hence, utilization of such waste is highly desirable for the date industry and for date cultivation, in which an increased income can be achieved for the sector.

Carbohydrate content

Aside from proximate components, sugar contents are significant nutritive components that provide energy to human body cells. Many studies were interested in the determination of carbohydrate composition of date flesh (Shinwari, 1993; Myhara *et al*.,1999; Al-Shahib and Marshall, 2003; Al Jasser, 2009; Al-Juhaimi *et al.*, 2014), while only a few studies determined the carbohydrate content of DPK (Habib and Ibrahim, 2008; Habib *et al*., 2013). Carbohydrates are the major chemical constituents of dates flesh and kernels, containing mainly reducing sugars such as glucose and fructose, and also non-reducing sugars such as sucrose, and small amounts of polysaccharides such as cellulose and starch (Al-Shahib and Marshal, 2003). According to Salem and Hegazi (1971), polysaccharides in the flesh and kernels of dates consist of xylose, arabinose, glucose, and galactose.

Research on DPK done by Habib and Ibrahim (2008) reported that the total carbohydrates content of 18 leading varieties kernels from DPK cultivated in the United Arab Emirates consisted of approximately 2% to 5%, which is slightly below the range of the carbohydrate in the current study (8.56%, Table 1). In this study, sucrose (0.55%), fructose (0.25%), glucose (0.2%) and maltose (Not detected) were measured only, while other sugars; Raffinose, Stachyose, Galactose and other carbohydrates including xylose and arabinose were not individually measured in this study as well as glucomannans and galactomannans, which have been determined in other studies on other DPK types (Salem and Hegazi, 1971; Ishrud *et al*., 2001a; Ishrud *et al*., 2001b; Habib and Ibrahim, 2009; Al-Juhaimi *et al*., 2012). Salem and Hegazi (1971) measured the carbohydrate contents in DPK and date flesh, in which glucose, fructose, and sucrose were detected. Notably, mannose and maltose sugars were also detected in the same study and found only in DPK but not in the date flesh. Therefore, the total amount of carbohydrates (8.68%) of BDPK, can be attributed to the presence of other types of carbohydrates which were not determined in this study.

Protein content of BDPK

The kernels of date fruits also contain protein. Stegmann *et al.* (1986) studied Iranian cultivars and reported that the kernels of the Sayer cultivar had the highest protein content of 10.6% compared to three other cultivars grown in Iran. In other varieties of date, the protein content was as high as 6.42% in six cultivars of dates growing in the south of Libya (Tasfert, Taghiat, Adwi, Seloulou, Aspear and Taleesi) (El-Shurafa *et al*., 1982). Alshowiman and BaOsman (1992) reported that the protein content of kernels from seven cultivars (Sheshi, Shaqra, Saqae, Maktomey, Sekkeri, Berni, and Barhi) growing in different regions of Saudi Arabia ranged from 4.79%

Table 2. Amino acids content of Barhi date palm kernels. (Protein is ~5.3%)

Amino acid	g/100g
Hydroxyproline	0.03 ± 0.004
Aspartic Acid	0.32 ± 0.004
Serine	0.17 ± 0.005
Glutamic Acid	0.67 ± 0.003
Glycine	0.18 ± 0.006
Histidine	0.07 ± 0.004
Arginine	0.44 ± 0.010
Threonine	0.13 ± 0.000
Alanine	0.21 ± 0.017
Proline	0.16 ± 0.006
Thyrosine	0.06 ± 0.003
Valine	0.16 ± 0.001
Methionine	0.01 ± 0.003
Lysine	0.19 ± 0.008
Isoleusine	0.09 ± 0.001
Leusine	0.205 ± 0.003
Phenylalanine	0.12 ± 0.006

Values are mean of two replicates ± standard deviation.

to 7.50%. In this study, the protein content in BDPK was 5.29%. Differences in nutritional composition of DPK among the different studied varieties grown in different countries could be attributed to different factors such as the differences in time of harvest, post-harvest treatments, and the use of fertilizers (Habib and Ibrahim, 2009).

Amino acids content of BDPK

The amino acid composition of a protein is important in terms of the nutritional value of the protein source and in particular the content of the essential amino acid which cannot be synthesized by humans and needs to be supplied in the diet. Most of the previous studies on the amino acid content focused on the flesh of date palm (Hussein and El Zeid, 1975; Auda *et al.*, 1976; Al-Hooti *et al.*, 1998; Al-Shahib and Marshall, 2003; Gehring *et al.*, 2011; Akasha, 2014) whereas limited research have been done to measure the amino acid composition of DPK. Hussein and El Zeid (1975) measured the amino acids content of DPK from Khalas variety and found that they contain at least sixteen amino acids including significant amounts of essential amino acids.

In the present study, it was found that BDPK contained good nutritionally useful quantities of essential amino acids. Seventeen amino acids were detected in BDPK, in which, glutamic acid (12.67%) was the most abundant amino acid, followed by arginine (8.31%), aspartic acid (6.05%), alanine (3.97%) and leucine (3.87%), (Table 2). These observations were in accordance with those reported by Bouaziz *et al.* (2008). In their studies of the amino acid composition of Tunisian DPK, Deglet Nour, and Allig varieties, seventeen amino acids were also detected and identified, in which glutamic acid was the predominant amino acid of total amino acids in both varieties. They also found that most of the amino acid in the kernels of Deglet Nour variety (17.83%) were present at higher concentrations than those in Allig variety (16.77%), followed by Arginine (9.27%-10.5%), aspartic acid (7.34%-8.39%), leucine (5.24%-5.5%), and glycine (4.2%-4.5%). It can be seen that their values were higher than found in this study as shown in Table 2. These variations in the reported concentration of amino acid could be attributed to the differences in the composition of amino acid between varieties. Notably, BDPK contains eight essential amino acids (lysine, isoleucine, leucine, methionine, threonine, valine, histidine, and phenylalanine), except tryptophan. The disappearance of tryptophan from BDPK might be attributed to destruction during hydrolysis by concentrated hydrochloric acid and could also account for the loss of cysteine as reported by Alshowiman and BaOsman (1992). These data revealed that, the BDPK containing essential nutritional contents that are necessary to human health.

Mineral composition of BDPK

Results from this study clearly show that BDPK has significant mineral contents (Table 3). The potassium concentration was the highest (239.1 mg/100 g), followed in descending order by magnesium (176.39 mg/100g), phosphorus (123.13 mg/100 g), calcium (38.94 mg/100g) and sodium (12.98 mg/100g). The current results seem to confirm those mentioned by Habib and Ibrahim (2009) and Al-Farsi *et al.* (2007), except for magnesium content. The variation in magnesium content could be explained by many factors such as variety, soil type, agro-climatic changes and amount of fertilizer (Assirey, 2015). The findings of this study indicate that BDPK contains suitable concentrations of potassium, calcium, and phosphorus, which are important for metabolism in human cells (GASIM, 1994). Minerals have many health benefits; they are vital to overall mental and physical well-being (Habib and Ibrahim, 2009). Noteworthy, BDPK have relatively high potassium content compared to sodium content (Table 3). The high potassium to sodium ratio may be of health significance to patients with heart diseases.

Mineral content in DPK from various date palm

Table 3. Mineral contents of Barhi date palm kernels

Parameter	mg/100g
Aresenic	≤ 0.0001
Mercury	00.007 ± 0.001
Cadmium	0.0002 ± 0.001
Antimony	00.005 ± 0.003
Selenium	00.014 ± 0.004
Manganese	1.581 ± 0.03
Phosphorus	123.13 ± 1.25
Copper	01.58 ± 0.16
Lead	0.0017 ± 0.001
Stanum	01.53 ± 0.02
Zink	01.95 ± 0.06
Magnesium	176.39 ± 1.58
Ferum	05.57 ± 0.05
Calcium	38.94 ± 0.20
Potassium	239.11 ± 0.43
Sodium	12.98 ± 0.22

Values are mean of two replicates ± standard deviation

varieties have been reported by many researchers (Al-Farsi *et al*., 2005; Ismail *et al*., 2006; Khan *et al*., 2008; Chaira, *et al*., 2009; Habib and Ibrahim, 2009; Rock *et al*., 2009; Al-Juhaimi *et al*., 2014). Among the minerals of DPK of various varieties, potassium concentrations were reported at the high levels compared with those of others. (Ali-Mohamed and Khamis, 2004) reported the mineral composition of the DPK of six different cultivars of Bahraini DPK and showed that they were relatively rich source of potassium (486 mg/100g), followed by magnesium (66 mg/100 g), sodium (24 mg/100g) and calcium (10 mg/100g), but phosphorus was not detected. Whereas Besbes et al. (2004) also reported the mineral contents of two Tunisian cultivars (Deglet Nour and Allig). Their reports for potassium, phosphorus magnesium, calcium and sodium were (229-293 mg/100g), (68.3-83.6 mg/ 100g), (51.7-58.4 mg/ 100g), (28.9-38.8 mg/100g) and (10.3-10.4 mg/100g) respectively. These results show that the mineral variations in DPK can show considerable variations not only between the varieties in the same regions but also within the same varieties cultivated under different agro-climatic conditions (Al-Juhaimi *et al*., 2014).

Vitamin content of BDPK

Vitamins are essential nutrients to maintain human health. Despite these are required in very small quantity, they play crucial and specific functions in our body. Most of the data available in the literature have been for the vitamin content in date palm fruits,

Table 4. Vitamins contents of Barhi date palm kernels

Parameter	Concentration (mg/100g)
Vitamin E as α-tocopherol	0.009 ± 0.001
Vitamin B_3	2.050 ± 0.050
Vitamin B_5	40.42 ± 4.000
Vitamin B_8	1.200 ± 0.000
Vitamin B_{12}	2.000 ± 0.000

Values are mean of two replicates ± standard deviation.

which contain a moderate concentration of vitamins such as vitamin A, B1, B2 and nicotinic acid (El-Sohaimy and Hafez, 2010). In DPK, some oil soluble vitamins such as vitamin E have been identified by HPLC and GCMS (Abdalla *et al*., 2012). Vitamin E (tocopherols) is important to human health due to its antioxidant properties that can protect the body against oxidation reactions from free radicals, skin damage and aging by UV radiation. It also inhibits the growth of cancer cells and helps to lower the cholesterol levels (Sundram *et al*., 1989; Goh *et al*., 1994; Abdalla *et al*., 2012).

In the current study, it has been found that the vitamin contents of BDPK are 40.42 (mg/100 g) for vitamin B5, 2.05 (mg/100 g) for vitamin B3, 2.0 (mg/100 g) for vitamin B12, 1.20 (mg/100 g) for vitamin B3, and 0.01 (mg/100 g) for vitamin E (α-tocopherol). Among the vitamins present in BDPK, vitamin B5 concentrations were found at high levels compared with those of others. Vitamin B5, also called pantothenic acid, is one of eight B vitamins, often referred to as B complex vitamins. Such vitamins act as co-enzymes to assist the working of every cell in human body. These vitamins are involved in the synthesis of new cells as well as in the metabolism of fat, protein, and carbohydrates. They also help the nervous system function properly. All B vitamins are water-soluble, meaning that the body does not store them. In addition to playing a critical role in the breakdown of fats and carbohydrates for energy, vitamin B5 is critical to the manufacture of red blood cells (RBC). Moreover, vitamin B5 is important in maintaining a healthy digestive tract. Vitamin contents of BDPK are illustrated in Table 4.

Fatty acid composition of BDPK's oil

Fatty acids profile was identified in BDPK by gas chromatography apparatus as shown in Table 5. From the results obtained in this study, it can be seen that BDPK contain a substantial amount of oil (08.69%) that needed to be characterized, and therefore the fatty acid composition of BDPK was established.

Oleic acid (C18:1), the monounsaturated fatty acid, was found to be the main fatty acid present in BDPK (40.93%), which is in agreement with previous reports (Al-Hooti *et al*., 1998; Basuny and Al-Marzooq, 2011). Oleic acid (C18:1), linoleic acid (C18:2), myristic acid (C14:0), palmitic acid (C16:0) and Lauric acid (C12:0) which together compose about 93% of the total fatty acids in BDPK.

High oleic oils normally have positive health effects because of their low saturated fatty acid levels, minimal trans-isomer levels, high oxidative stability and potential to reduce low-density lipoprotein (LDL) cholesterol in the blood (Habib *et al*., 2013). Liquid oils with high oleic fatty acid contents normally show good flavor and frying stability (Yong and Salimon, 2006). Nehdi *et al.* (2010) reported that oleic acid in Tunisian date kernels comprises over 50% of the fatty acid content and represents the most abundant fatty acid in the oil, followed by linoleic acid (19%), lauric acid (10%) and palmitic acid (10%). These results were in agreement with those reported by Saafi *et al*. (2008).

Besbes *et al*. (2004) showed that oleic acid was also the major unsaturated fatty acid (41.3% - 47.7%), while lauric acid was the major saturated fatty acid (17.8%) in date kernels from Tunisian date, Deglet Nour. These results were in agreement with that reported by Saafi *et al.* (2008) as well as with the results of the present study. These differences in fatty acid components depend on date varieties and their origins.

The findings indicate that BDPK oil could represent a good source of C18:1 fatty acid. DPK has a very intense yellow colour in comparison with other vegetable oils studied by Erol *et al.* (2011). This suggests the presence of a significant quantity of the yellow pigment, carotenoid. This pigment is responsible for the absorption of ultraviolet radiations measured by Besbes *et al*. (2004).

Interestingly, Basuny and Al-Marzooq (2011), extracted oil from Khalas cv. and used it to replace conventional oil in producing mayonnaise. In their study, they evaluated the sensory qualities of oil from DPK and compared it with the commercial mayonnaise prepared from corn oil. Their data demonstrated that mayonnaise containing DPK oil, was superior in sensory characteristics when compared with control manufactured from corn oil. They showed that the DPK oil could be used as non-traditional oil in some food processing such as mayonnaise products. In the same study, Basuny and Al-Marzooq (2011) measured the fatty acids composition of palm kernel oil and compared it with

Table 5. Fatty acid content of Barhi date palm kernels (mg/100 g sample)

Parameter	FA Methyl Ester	mg/100g DPK
C8	Caprylic	00.35 ± 0.010
C10	Capric	00.36 ± 0.010
C12	Lauric	20.27 ± 0.290
C14	Myristic	12.29 ± 0.090
C15	Pentadecanoic	00.07 ± 0.003
C16	Palmitic	11.10 ± 0.020
C16:1	Palmitoleic	00.41 ± 0.004
C17	Heptadecanoic	00.12 ± 0.004
C17:1	Cis-10-Heptadecanoic	00.08 ± 0.001
C18	Stearic	03.22 ± 0.020
C18:1n9c	Oleic	40.93 ± 0.330
C18:2n6c	Linoleic (Cis)	08.74 ± 0.050
C18:3n3	a-Linolenic	00.12 ± 0.003
C20	Arachidic	00.49 ± 0.050
C20:1n9	Arachidonic	00.33 ± 0.002
C20:2	Cis-5,8,11,14,17-eicosapentaenoic	00.09 ± 0.040
C20:3n6	Behenic	0.31 ± 0.007
C20:3n3	Erucic	0.21 ± 0.000
C21:0	Cis-4,7,10,13,16,19-Docosahexaenoic	0.52 ± 0.005
	Total	100.00

Values are mean of two replicates ± standard deviation.

DPK oil. The results showed that DPK oil had a higher unsaturated fatty acid content (49.00%) than palm kernel oil (29.71%).

The degree of unsaturation of DPK oil has been found to be lower than that of common vegetable oils because DPK oil has much lower linoleic acid content. In spite of this low level of unsaturation, the oxidative stability of DPK oil is higher than that of most vegetable oils and comparable to that of olive oil. This may be explained by the low content of polyunsaturated fatty acid in DPK oil and in olive oil compared to the common vegetable oil (Basuny and Al-Marzooq, 2011). Moreover, the high relative percentages of oleic acid and natural antioxidant polyphenols of BDPK (data not shown) can be another contributing factor. BDPK oil could be therefore, easily conserved due to their high oxidative stability. Regarding these specificities, BDPK or this by-product “waste” could be incorporated in food industries and cosmetics.

The proximate analyses values of BDPK found in the present study are within the range of values presented earlier in the literature. Exploring potential recycling and application of BDPK is extremely important for the countries with a well-established date fruit industry. It is anticipated that the development of specialty products and value added wastes will definitely increase the attraction toward the Iraqi-, Arabs- and Muslims date industry. With the scale of the international date industry, a large quantity of BDPK can easily be obtained from date palm groves or processing stations. Given the approximate annual yield of DPK, in most producing countries, which ranges from 1000 to 10000 tons (Devshony, 1992), it is, therefore important to find ways to exploit this largely abundant, low-value waste product which is highly possible and applicable. BDPK can be utilised as a valuable ingredient in the food and pharmaceutical industries. It is also important to note that full usage of this fruit waste will also add immense value and security to all date producers. Consequently, the additional significant income that can be generated from date wastes would encourage farmers to begin and continue cultivating this draught-resistant fruit crop locally and internationally.

Conclusion

The findings of the current study demonstrate that BDPK could be valuable and excellent source of food ingredients with interesting technological functionality that could be used as low-priced nutritive supplementary source for human diet. Considering the chemical composition, it can be concluded that BDPK can be regarded as an important and non- conventional source of protein, dietary fibre, oil and some important minerals which may, therefore, be used as ingredients in the production of some functional foods for human consumption through enhancing the nutritional value of several food products, for example, increasing the fibre content of bakery products due to oil and water uptake, and swelling capacity of DF. However due to less work on nutritional properties of DPK, individuals are less mindful for their benefits, hence a vast amount of DPK are squandered. Future studies will be conducted on the polyphenolic and bioactive compounds of BDPK such as dietary fibre, which can exhibit unique qualities, of them; antioxidant activity. Giving their importance in developing functional foods from BDPK, carbohydrates, and especially, soluble and insoluble DF and resistant starch should be further studied as well as their potential biological effects on human health. Exploitation of such waste can, therefore have economic benefits to producers, leading to a greater diversity of products and valorisation of a waste that currently has a scarce use, and directed mainly to human usage.

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