

The Role of Date Palm Fruit in Improving Human Health

MUNEERA QASSIM AL-MSSALLEM



ABSTRACT

Despite the fact that date palm (*Phoenix dactylifera* L.) fruits are characterised by a high content of carbohydrates, the quality of their carbohydrates results in a low glycaemic response. In comparison to common fruits consumed such as strawberries and guava, Date Palm Fruits (DPFs) have exhibited the highest antioxidant activity. DPFs have been shown to act effectively as free radical scavengers due to their content of bioactive compounds such as phenolic acids, carotenoids, flavonoids, and polyphenols. These bioactive substances can absorb and neutralise free radical intermediates resulting from oxidation reactions in the human body. The vital action of DPF constituents contributes significantly in reducing physiological cellular damage and protecting the human body against oxidative stress-related diseases such as cardiovascular diseases, neurodegenerative diseases and cancer. From this point, it can be concluded that regular consumption of DPFs may be associated with a reduced risk of some chronic diseases due to the antioxidant, antimicrobial, antidiabetic, anticancer, and antimutagenic activities of DPFs. In fact, DPFs have been widely used since ancient times in folk medicine to treat various health conditions, demonstrating the importance of DPFs as a nutraceutical and a source of functional nourishment. This review aims to consolidate most of the work carried out on DPFs in terms of their contents of nutrients and biologically active components such as phenolic compounds, with special emphasis on their functions in improving general health.

Keywords: Antioxidant, Bioactive compounds, Nutrients, Oxidative stress

INTRODUCTION

The date palm (*Phoenix dactylifera* L.) tree is one of the oldest trees that have been cultivated since the dawn of agriculture [1], and its fruits possess a substantial number of nutritional and functional constituents [2-4]. The nutritional composition of DPFs certainly relies upon their cultivar and ripening stage. The main constituents of DPFs are carbohydrates in the form of glucose, fructose, and Non Starch Polysaccharides (NSPs) [2,5]. Although there is a high content of simple sugars, the quality of carbohydrates in DPFs, which has been determined by the Glycaemic Index (GI), has shown that most date varieties have low GI values [5-9]. Moreover, DPFs are rich in minerals such as potassium, sodium, and magnesium [2]. However, the concentrations of water and fat soluble vitamins in DPFs were found to be low. Additionally, DPFs possess small quantities of protein and fat [2,3]. In addition, DPFs exhibit considerable quantities of biologically active molecules [10,11]. The contents of these bioactive compounds in DPFs vary significantly based on several factors, such as date palm cultivars, the stage of fruit development, post harvest processing, soil conditions, and geographical location [1,10-12].

In fact, the bioactive compounds in DPFs exhibit antioxidant activity as well as antimicrobial and antimutagenic properties. The antioxidant activity in DPFs was found to be high [13]. This characteristic of DPF substances plays a crucial role in the prevention of oxidative stress damage in the human body because DPF constituents act as free radical scavengers [1,10,12,14]. Studies have shown that high consumption of fruits is associated with a low incidence of chronic degenerative diseases [15]. However, DPF is still one of the underexploited healthy fruits [16]. This review explores the importance of DPFs as an excellent source of nutrients and functional constituents, with an emphasis on the beneficial health effects of DPF constituents on the human body.

Quantity Verse Quality of Carbohydrates in Date Palm Fruits

Carbohydrates are the predominant constituents in DPFs, and the carbohydrate content reaches 53 gm/100 gm FW (fresh weight) in the

Rutab stage (partially ripened stage of DPF) and 73 gm/100 gm FW in the Tamer stage (fully ripened stage) [2]. The main carbohydrates in DPFs are monosaccharides, which consist of glucose (23-30%) and fructose (19-28%), and NSPs (7-10%) [2,5]. A recent study has found that consuming approximately 100 gm of DPFs results in the intake of approximately, 11%, 16%, and 24% of the daily Recommended Dietary Allowances (RDA) of energy, simple carbohydrates, and NSPs, respectively [17].

The Glycaemic and Insulinaemic Indices of Date Palm Fruits

The assessment of the quality of carbohydrates, which is measured by the GI value, has shown that most DPFs have a low GI value [5-9]. The average GI value of more than 30 cultivars of DPFs was approximately 53 [Table/Fig-1] [5,6,8,9,18-22]. The low GI value of most DPFs is attributed to the presence of considerable quantities of fructose and NSPs [2]. The inverse correlation between the GI value and the fructose has been reported [18]. Moreover, the GI value can be further reduced by consuming DPFs with yoghurt, yoghurt drinks, or nuts [Table/Fig-2] [5-9,18-22]. On the other hand, the blood glucose response to dates was modestly increased when the dates were consumed with Arabic coffee [6]. However, one study found that drinking Arabic coffee did not adversely affect the blood glucose response to dates [20].

Moreover, the Insulinaemic Index (II) of the Khalas date variety at the Tamer stage was determined, and it was found that the consumption of dates has an intermediate impact on the insulinaemic response [Table/Fig-2] [6].

Glycaemic Load of Date Palm Fruits

The amount of carbohydrates in the DPFs and the rate and extent of the digestion of these carbohydrates are determined using Glycaemic Load (GL). The GL was introduced to simultaneously assess the quality and quantity of carbohydrates consumed [23]. The GL value of DPFs was calculated for a serving size of three DPFs (27 gm), and it was found that DPFs have a low GL with an average value of 9 [Table/Fig-2]. This finding confirms the minimal

Dates varieties	Total CHO	Available CHO	Available CHO in serving size	GI value	GI level	GL value	GL level
Ajwah, Qassim, Saudi [8]	71.3	61.3	16.4	56	medium	9	low
Birhi (mean of two studies) [8,21]	72.8	57.3	15.4	56	medium	9	low
Bo ma'an (mean of two studies) [9,22]	74.0	64.0	17.2	38	low	7	low
Dabbas, UAE [9]	70.8	68.4	18.4	49	low	9	low
Deglet Noor, Algeria [5]	84.1	70.9	19.1	52	low	10	low
Fardh (mean of two studies) [9,18]	68.1	61.4	16.5	53	low	9	low
H'mira, Algeria [5]	72.2	58.4	15.7	48	low	8	low
Khalas (mean of six studies) [6,9,18-20,22]	70.2	64.2	17.3	48	low	8	low
Khasab, Oman [18]	67.2	54.8	14.8	55	low	8	low
Khudhary (mean of two studies) [8,21]	74.5	61.3	16.5	59	medium	10	low
Lulu, UAE [9]	70.8	69.0	18.6	53	low	10	low
Maktoomi, Qassim, Saudi [8]	72.9	61.3	16.5	71	high	12	medium
Medjool, Qassim, Saudi [8]	70.9	61.3	16.5	55	low	9	low
Nabtat-ali, Qassim, Saudi [8]	72.2	61.3	16.5	60	medium	10	low
Nabtat-seif, Qassim, Saudi [8]	74.6	61.3	16.5	54	low	9	low
Nabut Seif, Riyadh, Saudi [21]	69.9	61.3	16.5	64	medium	11	medium
Nabut Sultan, Riyadh, Saudi [21]	69.9	61.3	16.5	51	low	8	low
Osilah, Qassim, Saudi [8]	60.6	53.5	14.4	56	medium	8	low
Rabiea, Riyadh, Saudi [21]	69.9	61.3	16.5	55	low	9	low
Rashodia, Qassim, Saudi [8]	74.3	61.3	16.5	51	low	8	low
Ruthana (mean of two studies) [8,21]	69.0	61.3	16.5	53	low	9	low
Sabaka, Qassim, Saudi [8]	71.9	61.3	16.5	55	low	9	low
Saqai (mean of two studies) [8,21]	69.3	61.3	16.5	51	low	8	low
Sellaj (mean of two studies) [8,21]	71.2	61.3	16.5	65	medium	11	medium
Shaqra, Qassim, Saudi [8]	74.7	61.3	16.5	43	low	7	low
Shishi, Qassim, Saudi [8]	69.6	61.3	16.5	50	low	8	low
Sukkary (mean of two studies) [8,21]	67.1	61.3	16.5	45	low	7	low
Tinnisine, Algeria [5]	68.6	56.1	15.1	44	low	7	low
Um-Kabar, Qassim, Saudi [8]	72.3	61.3	16.5	58	medium	10	low
Wannanah, Qassim, Saudi [8]	74.0	61.3	16.5	51	low	8	low

[Table/Fig-1]: Total carbohydrates (CHOs), available carbohydrates, glycaemic index (GI) and glycaemic load (GL) values, and glycaemic index and glycaemic load levels of date palm fruits at the Tamer stage.

Item	Serving size (g)	Available CHOs (g)	GI value	GI level	GL value	GL level	II value
Date palm fruit (Tamer stage) [5,6,8,9,18,21,22]	27	17	52	low	9	low	64
Date palm fruit (Tamer stage, 27 gm) served with 125 gm full fat plain yoghurt [19]	152	24	29	low	7	low	
Date palm fruit (Rutab stage) [19]	27	12	47	low	6	low	
Date palm fruit (Rutab stage, 27 gm) served with 125 gm full fat plain yoghurt [19]	152	19	37	low	7	low	
Date palm fruit (Tamer stage, 27 gm) served with 200 mL Arabic coffee drink [6,20]	227	17	58	medium	10	low	62
Date palm fruit (Tamer stage, 27 gm) stuffed with 12 gm nuts [7]	39	18	42	low	8	low	

[Table/Fig-2]: Total available carbohydrates (CHOs), glycaemic index (GI) and glycaemic load (GL) values, glycaemic index and glycaemic load levels, and insulinaemic index (II) of date palm fruits at the Rutab and Tamer stages, served with yoghurt and Arabic coffee, and stuffed with nuts.

effect of both the quality and quantity of DPF carbohydrates. The GL of DPFs is a good indicator to estimate the overall impact of carbohydrates on the blood glucose response [24]. Both the GI and GL values of DPFs should be taken into account when planning to include DPFs in a diabetic patient's diet. It has been found that the high consumption of low GL foods was associated with reducing the risk of developing type 2 diabetes [25].

Functional Components in Date Palm Fruits Bioactive Compound Contents

Bioactive compounds are naturally produced as secondary metabolites and most of them are modulators of metabolic processes; therefore, they are not often required for the daily functioning of living organisms [26]. In DPFs, the bioactive

compounds can be classified into two groups: nutritive and non nutritive bioactive compounds. Examples of these two groups and their functional activities are demonstrated in the [Table/Fig-3] [1,2,5,10,11,27-32].

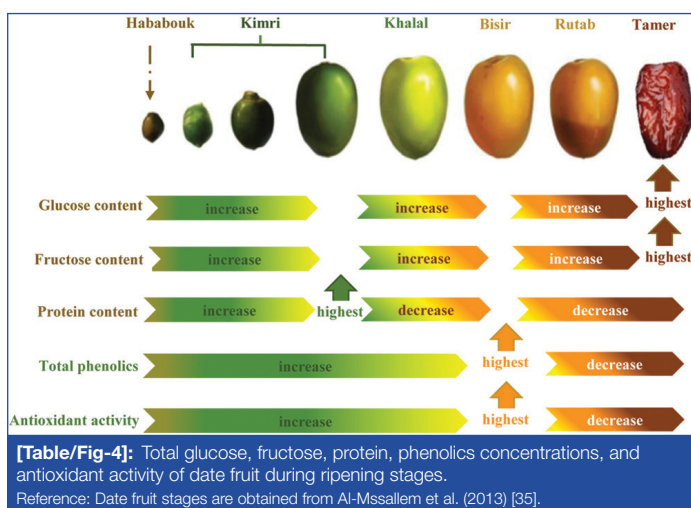
Antioxidant Content in Date Palm Fruits

The antioxidant content in DPFs has been extensively studied and was found to be the highest compared to the antioxidant contents of other commonly consumed fruits, such as strawberry, kiwi, guava, white pomegranate, and purple mulberry [13]. In general, the antioxidant activity of DPFs is significantly correlated with their total content of phenolic compounds [33]. However, there are some factors that can influence the activity of the antioxidants in DPFs, including date cultivars, ripening stages, and processing [10,33,34]. In fact,

	Function	Specific compounds
Bioactive nutritive compounds [2,5,27,30-32]	Inhibiting oxidative activity Scavenging free radicals Gastrointestinal activities Conferring taste	Vitamin C (ascorbic acid) Precursor vitamin A (β -carotene) Precursor vitamin E (α -tocopherol) Soluble NSPs (pectin and β -glucans) Insoluble NSPs (cellulose, hemicellulose, and lignin) Selenium
Bioactive non-nutritive compounds [1,2,10,11,27-29]	Inhibiting oxidative activity Scavenging free radicals Conferring taste and color to the date fruits	Phenolic acids Carotenoids Flavonoids Polyphenols Phytosterols

[Table/Fig-3]: Classification of bioactive compounds in date palm fruits and their functional properties.

it has been found that the antioxidant activity in the Khalas cultivar was higher than that in the other cultivars [11]. Moreover, the highest antioxidant activity occurs at the Bisir stage of DPF development [Table/Fig-4], and this activity gradually decreases at the Tamer stage [34]. This reflects the inverse relationship between the ripening stage of DPFs and the antioxidant activity [Table/Fig-4], starting from the Bisir stage (earliest stage of ripeness) of DPF development [34]. Additionally, it has been reported that date processing, such as sun drying and storage, caused a reduction in the total antioxidant activity. This reduction is possibly due to enzymatic oxidation or decomposition of natural antioxidants such as the conversion of soluble tannins into insoluble tannins [2,11].



[Table/Fig-4]: Total glucose, fructose, protein, phenolics concentrations, and antioxidant activity of date fruit during ripening stages.

Reference: Date fruit stages are obtained from Al-Mssallem et al. (2013) [35].

The importance of the antioxidant properties of DPFs in the context of human health will be discussed below.

Nutritional and Functional Health Benefits of Date Palm Fruits

General Health Benefits

The beneficial effects of DPFs on human health are well documented. DPFs play an important role as a source of nutrients and functional ingredients. Interestingly, although DPFs consist mostly of easily absorbed carbohydrates in the form of glucose and fructose, no detrimental effect has been observed on serum glucose or triglycerides when the DPFs have been consumed by healthy subjects [36]. In fact, DPFs are a good source of NSPs, and daily consumption of approximately nine DPFs can contribute approximately one-fourth of the daily RDA of NSPs [17,37]. The NSPs exert an important role in improving gastrointestinal functions, and thus date palm fruits can be used as a natural laxative to regulate intestinal transit and promote regular bowel movements [Table/Fig-5] [2,5,11,12,18,23,27,29,37,38,41,42,45-50,52-55].

Consumption of Date Palm Fruits and Controlling Weight

It is well known that a high NSP diet is highly recommended for maintaining a healthy body weight. As indicated above, DPFs are considered as a good source of NSPs [2]. Insoluble NSPs possess several health benefits, such as promoting weight control by increasing satiety and decreasing appetite [5]. Increased satiety leads to the promotion of energy intake control and a reduced risk of developing obesity and overweight [38]. Recently, it has been found that the association between DPF consumption and weight gain was negligible, indicating that the consumption of DPFs is not responsible for weight gain [37].

The Anti-diabetic Significance of Date Palm Fruits

One of the most important concerns among scientists is whether regular consumption of dates increases the risk of chronic diseases such as diabetes. The majority of scientists and the general public believe that diabetic patients should limit or even avoid consumption of DPFs due to their high content of monosaccharides such as glucose and fructose. However, the consumption of DPFs has not been found to have deleterious effects on serum glucose or to be associated with the prevalence of type 2 diabetes [17,36]. Indeed, DPF components may contribute to diabetes therapy and delay the development of diabetes-related complications [39]. The role of DPF constituents in controlling diabetes is still not fully understood. However, a study on alternative sweeteners showed that granulated date sugar exhibited a potential antidiabetic capacity, suggesting that sugar derived from dates is considered an excellent natural alternative sweetener for diabetic patients [30]. This antidiabetic effect could potentially be attributed to the presence of phenolic compounds that play a role in inhibiting α -glucosidase and α -amylase activity [30]. The inhibition of carbohydrate digestion may result in reducing the plasma glucose response to carbohydrates by reducing the availability of glucose to be absorbed from the small intestine [30].

Moreover, as stated previously, the mean GI value of DPFs falls into a low category [5-9]. The low glycaemic response to DPFs has not only been found in healthy individuals but was also found to be rather lower in type 2 diabetic patients [9]. This could be explained by the presence of a considerable amount of fructose and NSPs in DPFs. In fact, fructose is less diabetogenic than glucose [40]. It has been found that fructose lowers the plasma glucose response by inhibiting gluconeogenesis [41].

Furthermore, soluble and insoluble NSPs in DPFs play an important role in lowering the glycaemic response to DPFs [Table/Fig-5]. NSPs work as a barrier, delaying gastric emptying and reducing the digestion and absorption of carbohydrates [42]. It is evident that high-NSP foods are linked to a favourable effect on insulin sensitivity [43]. Studies have shown a significant association between dietary NSPs and decreased risk of diabetes, supporting the protective role of NSPs in the development of diabetes [23,44].

Moreover, the average GL value of DPFs, as shown in [Table/Fig-2], also falls into the low category. This indicates that both the quality and quantity of DPF carbohydrates exhibit a favourable influence on postprandial glucose response. In fact, GI and GL are potential tools for planning meals and assessing disease risk associated with dietary carbohydrate intake [25]. The importance of GI and GL in preventing type 2 diabetes has been reported in prospective cohort studies [23,44]. Therefore, DPFs may play a role in the management and prevention of type 2 diabetes among Arabian Peninsula inhabitants, where DPFs are frequently consumed on a daily basis.

Consumption of Date Palm Fruits during Late Pregnancy and Postpartum

One of the most interesting health issues related to DPF consumption is that they have been shown to have a contractile property on the uterus during the late trimester of pregnancy [45]. DPF components

Date palm fruits components	Common function	Health benefits	References
Carbohydrates			
Non-starch polysaccharides (NSPs)	1. Regulate intestinal transit 2. Promote regular bowel movements	• Improving gastrointestinal functions	[2,52]
	3. Increase satiety and decrease appetite 4. Control energy intake	• Maintaining body weight • Reducing the risk of developing obesity and overweight	[5,37,38]
	5. Delay gastric emptying 6. Lower the digestion and absorption of carbohydrates	• Protecting of developing the risk of type 2 diabetes • Lowering the glycaemic response • Improving insulin sensitivity	[23,42]
Fructose	1. Inhibit gluconeogenesis	• Lowering the plasma glucose response	[41]
Glucose	1. Provide instant energy	• Health option for breaking fast • Treating hypoglycaemia	[18,47]
Minerals			
Potassium (K)	1. Regulate blood pressure 2. Balance the body's nervous system and fluids 3. Regulate heart rate	• Protecting against strokes and coronary heart diseases	[53,54]
Bioactive compounds			
Phytosterols	1. Block the absorption of dietary cholesterol into the bloodstream 2. Inhibit the re-absorption of cholesterol from bile acids	• Lowering low density lipoprotein (LDL) cholesterol	[27]
Phenolics compounds	1. Inhibit α -glucosidase and α -amylase activity 2. Reduce the availability of glucose	• Lowering plasma glucose response	[29]
	3. Stimulate uterine myometrial cells 4. Increase sensitivity of the uterus 5. Reduce postpartum haemorrhage 6. Increase the production of milk	• Increasing cervical dilation and uterine contractions • Shortening the labour • Inducing labour naturally • Improving breastfeeding	[45,46]
	7. Scavenge free radicals 8. Inhibit oxidation reactions 9. Absorb and neutralize the free radicals 10. Prevent human cells damages 11. Inhibit antitumor activity 12. Interfere with the mutagenicity	• Improving general human health • Preventing against various oxidative stress-related diseases	[11,12,27,49,55]
	13. Activate the host immune system 14. Disrupt the bacterial membrane 15. Interfere with the bacterial enzymes	• Preventing or treating microbial infections	[48,50]

[Table/Fig-5]: Date palm fruit components and their common functions and health benefits.

also possess an oxytocin-like effect that stimulates uterine myometrial cells, increases sensitivity of the uterus, reduces the need for labour induction and augmentation, and induces labour naturally and spontaneously [45,46]. Studies have confirmed that the consumption of six DPFs per day during the final weeks of gestation is associated with an increase in cervical dilation and uterine contractions. It is recommended to include five to seven DPFs in the daily diet during the last weeks of the third trimester of pregnancy to make the delivery process easy and shorten the labour [46].

In addition, the ingestion of DPFs has a beneficial effect on women after delivery, by reducing postpartum haemorrhage and increasing the production of milk for breastfeeding [46].

Date Palm Fruits for Breaking Fast

DPFs are an important component of Middle Eastern diets, particularly for breaking the fast during fasting month worldwide [47]. In fact, DPFs provide instant energy due to their content of glucose and fructose [18]. These readily absorbed sugars make the DPFs the ideal option that is recommended for breaking long-term fasts. Moreover, as DPFs provide natural readily absorbed carbohydrates, this feature makes them the best for treating hypoglycaemia in diabetic patients.

Antioxidant, Anticancer and Antimutagenic Activities of Date Palm Fruits

Date palm trees are adapted to grow in harsh environments, such as arid and semi-arid regions. This adaptation may explain the high antioxidant activity exhibited by DPFs. The antioxidant properties of DPFs exert an effective role in protecting humans from oxidative species [11,12] by acting as free radical scavengers [10,27]. Free radicals are highly reactive components and are involved in activating carcinogenic substances, leading to cellular oxidation reactions,

which cause damage to the human cells [10]. The antioxidants in DPFs play a role in inhibiting oxidation reactions and scavenging any free radical intermediates by absorbing and neutralising these radicals [10,12]. This natural action of antioxidants protects the human body from oxidative stress-related diseases, such as neurodegenerative diseases and cancer [27]. Additionally, DPF components exhibit antitumour activities, which have been shown to be associated with the presence of β -glucan [48].

Furthermore, DPF components exert antimutagenic effects by interfering with mutagenicity [1,49]. This kind of activity refers to the presence of bioactive compounds present in DPFs, such as phenolic acids, anthocyanins, β -carotene and selenium [1,49].

Anti-inflammatory and Antimicrobial Activities of Date Palm Fruits

Some Saudi DPF cultivars have been tested for antibacterial properties, and it has been found that different cultivars exhibited different antibacterial activities [50]. The mechanism underlying the antimicrobial activities of DPFs may be attributed to the DPF content of phenolic components, which play an important role in activating the host immune system in addition to their ability to disrupt the bacterial membrane, or interfere with the bacterial enzymes [48]. In addition, DPF components play important roles as anti-inflammatory agents due to their strong ability to act as free radical scavengers [51]. The use of natural products, such as DPF extract, is an effective way to prevent or treat microbial infections [Table/Fig-5].

CONCLUSION(S)

This review demonstrated the functional properties of DPF contents where they play an important role in securing nutrients and protecting the human body from various chronic degenerative diseases due to their antidiabetic, antimicrobial, antimutagenic,

anti-inflammatory, and anticancer activities. Additionally, the low to moderate influences of DPFs on glycaemic and insulinaemic responses, and their high non starch polysaccharide content indicates that patients with diabetes can include five to seven DPFs into their diets on a daily basis. All these nutritional and functional benefits of DPFs suggest that DPF constituents can be a potential ingredient for nutraceutical and therapeutic applications. More research on the functional applications of DPFs is required to increase their use as a healthy food.

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PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Food Science and Nutrition, King Faisal University, Al-Ahsa, Saudi Arabia.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Muneera Qassim Al-Mssallem,
Assistant Professor, Food Science and Nutrition, King Faisal University,
Al-Ahsa, Saudi Arabia.
E-mail: mmssallem@kfu.edu.sa

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