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DATE (*PHOENIX DACTYLIFERA* L.) FRUITS AND SEEDS NANOTECHNOLOGY: A MINI REVIEW

Abdalla S. M. Ammar

Food Science and Technology Department, Faculty of Agriculture, Cairo University, Giza, Egypt

KEY WORDS:
nanoparticles, chemical composition, glycemic index, date fruits, date seeds

ABSTRACT

Nanotechnology is widely used in various sectors, and the increased interest in using nanoparticles in food technology is very clear. In this article, the history of dates and date production in Egypt was described. The anatomy of date fruit, classification of dates according to the moisture content, maturity stages, quality indices, and chemical composition, bioactive components and nutrients of dates, and the glycemic index and glycemic load of different varieties of dates worldwide were reviewed. The most recent date fruit nanoparticles (DFNPs) products and their applications for human health, such as anticancer, antimicrobial, and anti-fibrotic activities, were presented. The nutritional value of date kernels and their uses is of great interest in producing functional foods. Therefore, special emphasis has also been given to the novel date seed nanoparticles (DSNPs) products and their utilization. The role of these nanoparticles in nonfood sectors, such as yielding biodiesel, good thermal insulation in buildings, nanofillers as reinforcement materials in plastic, and as bio-adsorbent of pigments, was also considered.

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НАНОТЕХНОЛОГИИ НА ОСНОВЕ ПЛОДОВ И СЕМЯН ФИНИКА (*PHOENIX DACTYLIFERA* L.): МИНИ-ОБЗОР

Аммар А. С. М.

Факультет пищевой науки и технологии, сельскохозяйственный факультет, Каирский университет, Гиза, Египет

КЛЮЧЕВЫЕ СЛОВА:
наночастицы, химический состав, гликемический индекс, финики, семена (косточки) финика

АННОТАЦИЯ

Нанотехнологии широко используются в различных областях, и очевиден возросший интерес к использованию наночастиц в пищевых технологиях. В этой статье описывается история фиников и производство фиников в Египте. Рассмотрено строение финика и классификация по содержанию влаги, стадиям зрелости, показателям качества и химическому составу, биоактивным компонентам и питательным веществам, а также гликемический индекс и гликемическая нагрузка различных сортов фиников по всему миру. Представлены новейшие продукты на основе наночастиц фиников (DFNP), и описаны их полезные для здоровья человека свойства, такие как противораковая, противомикробная и антифиброзная активность. Пищевая ценность финиковых косточек и их применение представляют большой интерес для производства функциональных продуктов питания. Поэтому особое внимание уделено новым продуктам на основе наночастиц финиковых косточек (DSNP) и их использованию. Также рассмотрена роль этих наночастиц в непищевых отраслях, таких как получение биодизеля, теплоизоляция для зданий, нанонаполнители в качестве армирующих добавок для пластика и биоадсорбенты пигментов.

1. Introduction

The ancient Egyptians used the fruits to make date wine, and ate them at the harvesting. Dried dates either pitted or unpitted, can be consumed directly as a complete healthy, and tasty meal rich in nutrients and they are very suitable for a variety of recipes in food processing and bakeries.

Egypt is the largest date-producing country in the world, and the world annual production in 2023 was estimated at 9.661.174 tons [1]. The production of dates (*Phoenix dactylifera* L.) in Egypt was estimated at 1.867.064 tons in 2023 [1] and nearly all of the produced dates are consumed by Egyptians. Egypt is famous for planting dry dates and has various types of most preferred dates. According to the moisture content in fruits there are three types of dates: dry dates (⩽18 % moisture), semi-dry dates (more than 18 to less than 30 % moisture) and soft dates (rutab) (⩾30 % moisture). There are more than 200 varieties of dates with different shapes and flavors, however, all of them are the same in composition. Date fruits are composed of epicarp (skin), fleshy mesocarp (pulp), endocarp and a seed called a kernel or pit or pyrene (Figure 1). Date seeds are non-edible parts (wastes) of date fruit processing which are normally being disposed [2]. Based on the nutritional value of date kernels, various publications have proposed their use as an antioxidant and dietary fiber ingredient in noodles [3], as a fat replacer in meat balls [4], as a caffeine-free coffee alternative and animal feed component [5].

Alghazal et al. [6] produced fortified date paste with free and calcium alginate microencapsulated *Bifidobacterium lactis* Bb-12. Date paste showed a protective effect for encapsulated bacteria. Also, El-Kholy [7] produced yoghurt fortified with date seed powder as a natural prebiotic stabilizer.

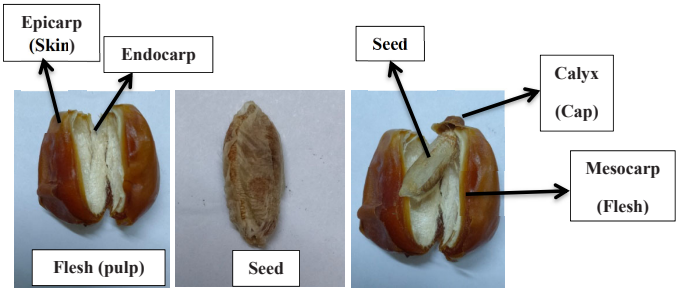

Figure 1. **The different fruiting components of the date palm fruit**
Рисунок 1. **Различные компоненты плода финиковой пальмы**

This article reviews using nanotechnology to produce various nanoparticles of date fruits and seeds and its utilization as well as quality indices, nutritional value and chemical composition of fruits.

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2. Objects and methods

The sources of information were the following scientific databases: Scopus, PubMed, Research Gate, Science Direct, and Google Scholar. The search strategy included the following keywords: nanoparticles, chemical composition, glycemic index, date fruits, date seeds. The following acceptance criteria for research characterization were considered: classification of dates according to the moisture content, maturity stages, quality indices, chemical composition, bioactive components and nutrients of dates, and the glycemic index and glycemic load of different varieties of dates worldwide. The most recent date fruit nanoparticles (DFNPs) and date seed nanoparticles (DSNPs) products and their applications.

The parameters of the publications were as follows: publications from 1982 until 2024 (40 references were selected for this review); language: English. Exclusion criteria: no access to the full-text articles. Based on the review, the author compiled information on the discussion of date (*Phoenix dactylifera* L.) fruits and seeds nanotechnology.

3. Nutritional value and chemical composition of dates

Dates have a high nutritional value. Dates contain minerals (i. e., K, Na, Mg, Ca and P). Fruits are a very good source of potassium. Furthermore, dates have trace elements including boron, cobalt, copper, fluorine, iron, manganese, selenium, and zinc. Also, fruits have vitamins B1, B2, B6, folic acid and ascorbic acid, proteins, fats, sugars. The sugar content of ripe dates represents about 80 % mainly in the form of sucrose, glucose and fructose [8]. Also, date fruits are rich in natural fibers. Always, dried dates contain double the level of nutrients especially carbohydrates, have lower water activity and consequently more shelf life in comparison to fresh dates. Also, bioactive ingredients are naturally present in dates especially phenolic acids, carotenoids, flavonoids, polyphenols, phytosterols, and α-tocopherols. Quality (degree of excellence of fresh date fruits) indicators include fruit size, chewiness, color, shape, cleanness and defects (i. e., sunburns, discoloration, insect infestation, skin separation, sugar crystallization, unpollinated fruits, fermented and spoiled dates). Growth stages and high-quality characteristics of date fruits are tabulated in Table 1.

The glycemic index (GI) is a scale that ranks food or drink by how much it increases blood sugar levels after it is consumed in comparison with pure glucose. Glycemic load (GL) = GI X dietary carbohydrate content (in grams) /100 [9,10]. Table 2 shows the glycemic index and glycemic load of different varieties of dates worldwide. Data in Table 2 exhibited that Sellaj date fruits had the highest GI value (74.6) followed by Maktoomi date fruits (71). While Zaghloul date fruits contained the lowest GI (30.3) followed by Boma'an date fruits (30.5).

4. Nanoparticles of date fruits and seeds

Nano-sized components are particles ranging from 1 to 100 nm in diameter with a high surface-to-volume ratio, which makes them more active and dispersed than larger one [16]. Food is considered nanofood if cultivated, produced, processed or packaged using nano techniques as well as with added nanoparticles [17,18].

Abdel Baky et al. [19] extended the date fruit shelf life and improved fruit quality using edible nanofilms for 2 months at 0 °C.

Ghani and Hussain [20] used the resultant extract either from date fruits or seeds as reducing and stabilizing agents for green synthesis of metal nanoparticles. Also, Khatami and Pourseyedi [21] performed green synthesis of silver nanoparticles (AgNPs) using date palm kernel aqueous extract. The synthesized silver nanoparticles (AgNPs) showed an antimicrobial effect. Khalil et al. [22] formulated date palm extract nanoemulsion. The nanoemulsion exhibited an anticancer effect. Likewise, Abdel-Alim et al. [23] biosynthesized AgNPs using the aqueous extracts of Egyptian date palm kernels. The AgNPs exhibited an antimicrobial effect. Also, Ma'abreh et al. [24] produced gel from nanoparticles of date palm syrup. Charti et al. [25] green synthesized zinc oxide nanoparticles using aqueous date palm wood extract. Hasson et al. [26] produced date palm silver nanoparticles that exhibited high antibacterial activity against gram-negative bacteria. Ali et al. [27] prepared a nanocatalyst consisting of CaO and Fe_3O_4 accompanied by $CaFe_2O_4$ which was used for catalytic transesterification of palm seed oil for yielding biodiesel. Nasabi et al. [28] used titanium dioxide nanoparticles as a decolorant for decolorizing date syrup. Tables 3 and 4 present a summary of novel date fruit nanoparticles (DFNPs) and date seed nanoparticles (DSNPs) and their utilization, respectively. Also, Figure 2 shows various functional foods and nonfood products generated from date seed nanoparticles (DSNPs).

Table 1. **Maturity stages and high-quality properties of date fruits [11]**

Таблица 1. **Стадии зрелости и показатели высокого качества фиников [11]**

Maturity stages	Quality criteria	Description
Hababouk, Kimri, Khalal, Rutab, and Tamr	Flesh	Thick
	Seed	Small
	Size	Adequate
	Brightness	Glossy
	Skin	Smooth
	Foreign materials	Free

Table 2. **The glycemic index and glycemic load of different varieties of dates worldwide**

Таблица 2. **Гликемический индекс и гликемическая нагрузка различных сортов фиников по всему миру**

Dates variety	GI	GL	References
Khalas	35.5	n/a	[12]
Barhi	49.7	n/a	
Boma'an	30.5	n/a	
Fara'd	54.0	n/a	[13]
Lulu	53.5	n/a	
Boma'an	46.3	n/a	
Dabbas	49.1	n/a	
Khalas	55.1	n/a	
Sellaj	74.6	24.0	[14]
Maktoomi	71.0	16.1	
Shaqra	42.8	9.2	
Sukkary	43.4	11.7	
Sag'ai	44.6	15.6	
Ajwah	55.9	8.5	
Ruthana	52.5	11.7	
Khudri	61.7	14.2	
Nabtat-ali	59.9	16.3	
Medjool	55.3	17.2	
Rashodia	50.9	12.4	
Partamoda	65.9	32.9	[15]
Malakabi	69.0	34.5	
Saadi	67.4	33.7	
Zaghloul	30.3	15.1	
Samani	34.6	17.3	

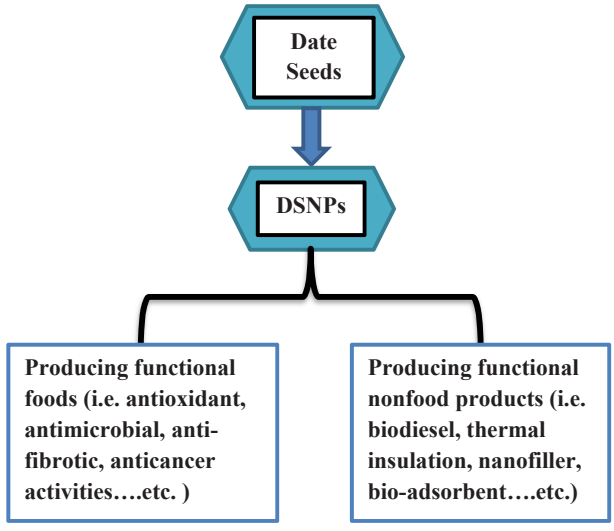

Figure 2. **Various functional foods and nonfood products generated from date seed nanoparticles (DSNPs)**

Рисунок 2. **Различные функциональные продукты питания и непищевые продукты, полученные из наночастиц финиковых косточек (DSNP)**

Table 3. **Novel date fruit nanoparticles (DFNPs) products and their applications**

Таблица 3. **Новые продукты на основе наночастиц фиников (DFNP) и их применение**

Date palm parts	DFNPs products	Application	References
Date fruit syrup	Producing gel from nanoparticles.	Gel nanoparticles to be used in developing date industry.	[24]
Ajwa date fruit	Ajwa nanopreparation	Ajwa nanopreparation protects from doxorubicin-associated cardiotoxicity.	[29]
Date fruits or seeds	Green synthesis of silver nanoparticles (AgNPs) using the extracts of date fruits or seeds	Increasing the anti-inflammatory effect of piroxicam drug and high antibacterial activity.	[21,26,30]
Date fruits	Date palm extract nanoemulsion.	The nanoemulsion exhibited an anticancer effect.	[22]
	Novel nano-extract of fresh fruit of “Hayany” [Egyptian date] was synthesized using a ball-milling technique.	Exhibiting the highest antimicrobial activity	[31]
	Using the powder form of date palm extract of Khalas cultivar and incorporating it into a nanolipid formulation such as a nanostructured lipid carrier prepared with palm oil.	Improving the antibacterial activity of the formulation (date palm extract + nanolipid)	[32]
	Using nano date press cake particles (waste generated from date juice extraction)	Producing soft carbonated date biobeverage rich in nutrients	[33]
	A date fruit extract loaded onto chitosan nanoparticles	Anti-fibrotic properties and improved liver function enzymes and endogenous antioxidant enzymes	[34]

Table 4. **Novel date seed nanoparticles (DSNPs) products and their utilization**

Таблица 4. **Новые продукты на основе наночастиц финиковых косточек (DSNP) и их применение**

Date palm parts	DSNPs products	Application	References
Date seeds	Synthesis of carbon nanotubes from Iraqi date palm seeds	Producing carbon nanotubes	[35]
	Preparing a nanocatalyst consisting of CaO and Fe_3O_4 accompanied by $CaFe_2O_4$	Transesterification of palm seed oil for yielding biodiesel	[27]
	Nanoemulsion of methanolic extract of date seeds	The methanolic extract of date seed-loaded nanoemulsion has more antioxidants and high drug release compared with conventional methanolic extract	[36]
	Nanoparticles of date pits	Nanoparticles of date pits and 50% by-volume epoxy provided good thermal insulation in buildings	[37]
	Nano date seed	Organic date seed nanofillers as reinforcement materials with MDPE and PET	[38]
	Synthesizing nanoparticles from date seeds (water and methanol extracts)	Enhancing their phenolic content and antioxidant activity to be used in food applications	[39]
	Fe_3O_4 nanoparticles in date seeds powder	Bio-adsorbent used to remove methylene blue from water	[40]

5. Conclusion

Currently, nanotechnology plays an important role in food technology. This study reviewed the most recent nanoparticles of date fruit products and their applications for human health, such as anticancer, antimicrobial, and anti-fibrotic activities. Likewise, the novel nanoparticles of date seed products and their utilization were reviewed. The role of these nanoparticles, such as yielding biodiesel, good thermal insulation in buildings, nanofillers as reinforcement materials in plastic, and bio-adsorbent of pigments was mentioned. Therefore, date kernels are of great interest in producing functional foods and very useful nonfood products.

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AUTHOR INFORMATION	СВЕДЕНИЯ ОБ АВТОРАХ
Affiliation	**Принадлежность к организации**
Abdalla S. M. Ammar, Professor, Food Science and Technology Department, Faculty of Agriculture, Cairo University Gamaa Street, Giza, 12613, Egypt Tel.: +2–0101–997–17–99 E-mail: abdallaammar@agr.cu.edu.eg ORCID: https://orcid.org/0000-0002-9919-8760	**Аммар Абдалла С. М.**, профессор, Кафедра науки о питании и технологии, Сельскохозяйственный факультет, Каирский Университет 12613, Египет, Гиза, ул. Гамаа Тел.: +2–0101–997–17–99 E-mail: abdallaammar@agr.cu.edu.eg ORCID: https://orcid.org/0000-0002-9919-8760
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