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Comparison of mineral compositions in seeds of different native and imported date cultivars

Mohammadreza Pourghayoumi[1], Kamal Gholamipour Fard[2], Sara Farokhzadeh[3*]

1- Mohammadreza Pourghayoumi, Research Assistant Professor, Date Palm and Tropical Fruits Research Center, Horticultural Science Research Institute, Agricultural Research, Education and Extension Organization (AREEO), Ahvaz, Iran.

2- Kamal Gholamipour Fard, Assistant Professor, Department of Plant Production, College of Agriculture and Natural Resources of Darab, Shiraz University, Darab, Iran.

3- Sara Farokhzadeh, PhD of Plant Breeding, Field and Horticultural Crops Research Department, Fras Agricultural and Natural Sciences Research and Education Center, Agricultural Research, Education and Extension Organization (AREEO), Shiraz, Iran.

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*Corresponding Author E-Mail:
Sfarokhzadeh87@gmail.com

ABSTRACT

Date palm seed is a rich source of minerals, fiber, carbohydrates, and contains high levels of antioxidant compounds, making it a cost-effective and beneficial ingredient for formulating food products in the country. The current research was conducted to investigate the mineral contents in the seeds of 15 cultivated date palm cultivars in Khuzestan province including native cultivars (‘Fersi’, ‘Satmaran’, ‘Zahidi’, ‘Deiri’, ‘Belyani’, ‘Bereim’, ‘Barhee’, ‘Sowaidani’, ‘Asharsi’, ‘Hallawi’, ‘Owaidi’, and ‘Piarom’), and imported cultivars (‘Medjool’, ‘Deglet Noor’, and ‘Thoory’), at the Date Palm and Tropical Fruits Research Center of Iran. These cultivars were analyzed using a completely random design with three replications. The results showed, there are significant differences in the mineral contents, including Fe, Mn, Cu, Zn, Na, K, and Ca in the seeds of different date cultivars. K had the highest content in date palm seeds compared to other elements, followed by Ca, Na, Zn, Fe, Mn, and Cu. The highest levels of Fe and Mn elements were observed in the seed of the ‘Deiri’ cultivar, while the highest levels of Cu and K were found in the seeds of the ‘Medjool’ cultivar. The ‘Deglet Noor’ cultivar had the highest contents of Na and Ca in its seeds. Also, the highest concentration of zinc element was detected in the seed of the ‘Barhee’ cultivar. In different date seeds, the highest positive and significant correlation was observed between Ca% and Na%. Based on the cluster analysis results, regarding seed mineral contents, the examined date palm cultivars were classified into four main groups. Overall, the seeds of examined date palm cultivars, contained significant but highly variable amounts of minerals, and the use of seeds from the ‘Deiri’ and ‘Barhee’ (native cultivars) and ‘Medjool’ (imported cultivar) is recommended as important components in the production of functional food products in the country.

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1. Introduction

Based on the agricultural statistics of Iran in the year 2021, the total area under date palm cultivation in Iran was 263,915 hectares. The cultivation area of mature date palms was 234,012 hectares and the area under new cultivation was 29,903 hectares. The total production of dates in the country was 1,491,528 tons, with an average yield of 6,478 kilograms per hectare. The Khuzestan province ranks third and fourth in terms of cultivation area and production among the date-producing provinces in Iran [1]. Dates contain a high percentage of carbohydrates, fiber, pectin, protein, fat, and minerals [2]. Information regarding the chemical composition and nutritional value of dates has been reported, but data on the composition and nutritional elements of date seeds in Iranian native cultivars are very limited. Studies on the chemical composition and nutritional value of date seeds in Omani cultivars have shown that date seeds contain 3.1-7.1% moisture, 2.3-6.4% protein, 5-13.2% fat, 0.9-1.8% ash, and 22.5-80.2% fiber. In addition, date seeds contain phenolic compounds (3102-4430 mg GAE/100 g) and antioxidants [3]. Phytochemical and chromatographic studies of date seeds have shown that other organic compounds such as proteins, alkaloids, steroids, vitamins, phenols, and terpenes are also found in date seeds [4-6]. In the Arabian Peninsula and some date-producing countries, date seeds are used to make coffee [7]. Depending on the cultivar, date seeds constitute 10 to 15% of the weight of the date fruit. However, date seeds are generally considered a low-value byproduct and are less utilized [8].

The significant amounts of proteins, minerals, and fats in date seeds make them valuable raw materials for animal feed production [9, 5]. In the past, date seeds were only used as animal feed, but recent studies have shown that date seeds have high nutritional and medicinal value. Due to the beneficial bioactive compounds present in date seeds, their use as a byproduct in the date industry is very important. Date seed powder is now used in many formulations such as sweet bread and various cakes [10]. Date seeds of Khalas, Khanizi, and Fard cultivars have been used in the preparation of Arabic coffee, as it is caffeine-free [11]. Furthermore, Khalas cultivar date seeds are used in the production of functional bread [12]. Additionally, date seed oil replaces other plant oils in the formulation of cosmetic products [13]. Research on the mineral composition in Bahraini date seeds has shown that they are rich in minerals [7]. Studies on the cultivars of date seeds in the UAE have shown that these seeds contain minerals such as sodium, potassium, magnesium, calcium, phosphorus, iron, manganese, zinc, copper, nickel, cobalt, chromium, lead, and cadmium [14]. Date seeds contain a small amount of selenium which plays a role as an antioxidant in human health and detoxifies the liver [15, 16]. Selenium deficiency in the body may be associated with infertility in men and women [17]. Furthermore, date seed waste is used in the production of biofuels and composites [18].

Some Iranian companies in provinces such as Mazandaran, Isfahan, Khuzestan, Bushehr, and Tehran have used date seed powder in animal feed and coffee production. However, given the high production of dates in Iran it is necessary to increase the number of these companies. Nevertheless, a significant amount of date seeds produced in date processing factories is wasted without optimal use. Date seeds contain high mineral composition that can be used as an inexpensive and functional source in food product formulations in the country. According to reports, the nutrient levels in different date cultivars vary significantly, and selecting the suitable cultivar for using date seed powder in the country's food industry is of paramount importance [14]. There are various date cultivars in the country, but information on their seed nutritional content is very limited. The objective of this research is to examine the levels of nutritional elements, including micronutrients and macronutrients, in the seeds of 15 cultivated date cultivars in Khuzestan province of Iran, including native cultivars of the province, well-known national cultivars, and commercial cultivars. Furthermore, this study investigates the relationships between mineral levels and the classification of different date seeds based on their nutritional content.

2- Materials and methods

This research was conducted to investigate the mineral elements in the seeds of various date

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palm cultivars at the Date Palm and Tropical Fruits Research Institute, located in Ahvaz, Khuzestan, with geographical coordinates of 48° 33′ east longitude and 31° 15′ north latitude, and an altitude of 12 m, during 2021-2022. For this purpose, the fruit of different cultivars, including native cultivars such as 'Fersi', 'Satmaran', 'Zahidi', 'Deiri', 'Belyani', 'Bereim', 'Barhee', 'Sowaidani', 'Asharsi', 'Hallawi', 'Owaidi', and 'Piarom' as well as imported cultivars like 'Medjool', 'Deglet Noor', and 'Thoory' were harvested at the fully ripe stage. Their seeds then were separated and transferred to the College of Agriculture and Natural Resources of Darab, for the determination of nutritional elements. All of these cultivars are present in the collection of date cultivars at the Date Palm and Tropical Fruits Research Institute. Thirty healthy and disease-free seeds were randomly selected from each cultivar for nutrient measurement. The cultivars were assessed using a completely randomized design (CRD) with three replications.

To measure the concentration of mineral elements, the acid digestion method was employed to prepare the samples. Date seed samples were dried in an oven at 75°C for 5 days until a constant weight was achieved. Following the drying process, 1 g of each sample was ground and placed in porcelain crucibles, then ashed in an electric furnace at 550°C for 5 hours. Subsequently, 5 mL of 2M HCl solution was added to the resulting ash for extraction. After heating, the solution was filtered through filter paper using boiling distilled water, and the extract volume was adjusted to 50 mL with distilled water [19]. This extract is directly used to measure the mineral elements of iron (Fe, mg.kg-1), manganese (Mn, $mg.kg^{-1}$), zinc (Zn, $mg.kg^{-1}$), copper (Cu, $mg.kg^{-1}$), sodium (Na, %), potassium (K, %), and calcium (Ca, %). The concentrations of micronutrients (Fe, Mn, Zn, and Cu) in the obtained extract were measured using an atomic absorption spectrometer (AAS; PG 990, PG Instruments Ltd., UK). While, the concentrations of macronutrients (Na, K, and Ca) were measured using a flame photometer (BWB XP, UK).

After sorting the data, statistical analyses were performed using various methods, including the normality test (Shapiro-Wilk test), simple analysis of variance, mean comparisons based on Duncan's test, Pearson correlation, and cluster analysis using Ward's method. Statistical calculations were performed using software programs such as SAS version 2.9, SPSS version 24, and the Excel program

3- Results and discussion

The results of variance analysis of the data related to micronutrient and macronutrient mineral elements in the seeds of 15 date cultivars revealed a significant difference among the seeds of different cultivars in terms of the amount of mineral elements such as Fe, Mn, Cu, Zn, Na, K, and Ca (Table 1). The average content of nutritional elements, in descending order, included K, Ca, Na, Zn, Fe, Mn, and Cu.

Table 1- Simple analysis of variance for concentrations of micronutrients and macronutrients in the seed of 15 date cultivars in the Ahvaz region of Iran

		Mean squares						
SOV	DF	Fe	Mn	Cu	Zn	Na	K	Ca
Cultivar	14	300.76**	146.10**	9.73**	66.40**	0.001**	0.006**	0.006**
Error	30	13.94	4.61	24.57	5.67	0.0001	0.001	0.0002
CV (%)	-	14.75	16.79	2.08	9.02	25.70	9.33	25.83

**: highly significant (α= 1%)

Our results are consistent with the findings of Ali Mohamed and Khamis [7]. They stated that, by examining the nutritional elements in date seeds, the concentration of K in date seeds is higher compared to other elements, and Fe, Mn, Zn, and Cu have the highest concentration. Golshan Tafti and Panahi [20] reported that the highest concentration of nutrients in the seeds of two cultivated date cultivars, Mazafati and Kalute, was Fe, Ca, cobalt (Co), Na, Zn, and Mn, respectively. They also mentioned that there is a lower amount of phosphorus (P) and K in the seeds of Mazafati and Kalute cultivars, which differs from our results. They stated that the levels of Na, Ca, and Cu in Mazafati date seeds are consistent across different regions. Another study on 11 date varieties in the Qassim region of Saudi Arabia reported that among macronutrients, Ca and K had higher concentrations than other elements [21]. Sawaya et al [22] also stated that K was the most abundant mineral in the seeds of Ruzeiz

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and Sifri date cultivars, while Na had the lowest concentration among macronutrients. Nehdi et al. [23] mentioned that the major elements in the seeds of Canary Island palms were K, magnesium (Mg), Ca, and P, respectively. Other studies have reported that the relative order of mineral concentrations in date seeds at harvest time were Ca < P < K < Mg for macronutrients and Fe < Zn < Mn < Cu for micronutrients [24]. Habib and Ibrahim [14] stated that date seeds contain significant but variable amounts of nutrients depending on the variety. They also emphasized that all varieties are an excellent source of dietary fiber, making them important for nutritional purposes in functional foods. The differences in nutrient levels in date seeds across different regions may be due to variations in cultivars, genetics, harvest times, environmental factors, and differences in palm nutrition and irrigation [5, 14, 25]. The high K content in various date cultivars is nutritionally important as K acts as an electrolyte and plays a vital role in kidney function, muscle cell contraction, and nerve function. It also aids in protein and carbohydrate metabolism for energy production and regulates heart rhythm [26, 27]. The recommended daily intake of K for adults is 2000 mg/day. In our study, the K content in the seeds of the investigated date cultivars ranged from 0.29 to 0.46% (Figure 1). The 'Medjool', which is an imported cultivar currently being developed in the country, had the highest K content in its seeds; however, there was no statistically significant difference between the K content of the Medjool cultivar and the Thoory and Bereim cultivars. The lowest K content was found in the Stamaran cultivar. Additionally, no significant difference was observed between the K content of the Stamaran cultivar and the Deglet Noor, Hallawi, Ashrasi, Owaydi, and Piarom cultivars (Figure 1).

Our results showed that the Ca content in the seeds of various date cultivars ranged from 0.014 to 0.195%. The highest Ca content in date seeds was observed in the imported Thoory cultivar, which had a significant difference compared to other date cultivars. The Owaydi cultivar had the lowest Ca content. However, there was no significant difference between the Ca content of the Owaydi cultivar and the Zahidi, Deiri, Stamaran, Deglet Noor, and Fersi cultivars (Figure 1). The Ca and P play an important role in bone formation, muscle contraction regulation, and nerve excitability. Calcium helps to reduce blood pressure and the risk of colon cancer [28]. The recommended daily intake of Ca for adults is 800 mg/day while for adolescents it is 1200 to 1500 mg/day [29].

The Na content in the seeds of the investigated date cultivars ranged from 0.014 to 0.066%. Generally, the Na content in the evaluated date cultivars was relatively low, and the lowest Na content was found in the Deglet Noor cultivar, making it suitable for individuals with high blood pressure. However, there was no significant difference between the Na content of the Deglet Noor cultivar and the native cultivars of Ashrasi, Owaydi, Stamaran, Hallawi, Zahidi, Fersi, as well as the imported Medjool cultivar. The highest Na content was observed in the Thoory cultivar (Figure 1). Sodium is crucial for proper cell function. The recommended daily intake of Na is 500 mg. Excessive Na consumption can lead to increased blood pressure [30].

On average, among the trace elements, Zn was the predominant micronutrient in the date seeds (Table 2). The Barhee cultivar had the highest amount of Zn in its seeds (37.65 $mg.kg^{-1}$), and statistically significant differences were observed in the Zn content between the Barhee cultivar and other cultivars except for the Stamaran cultivar.

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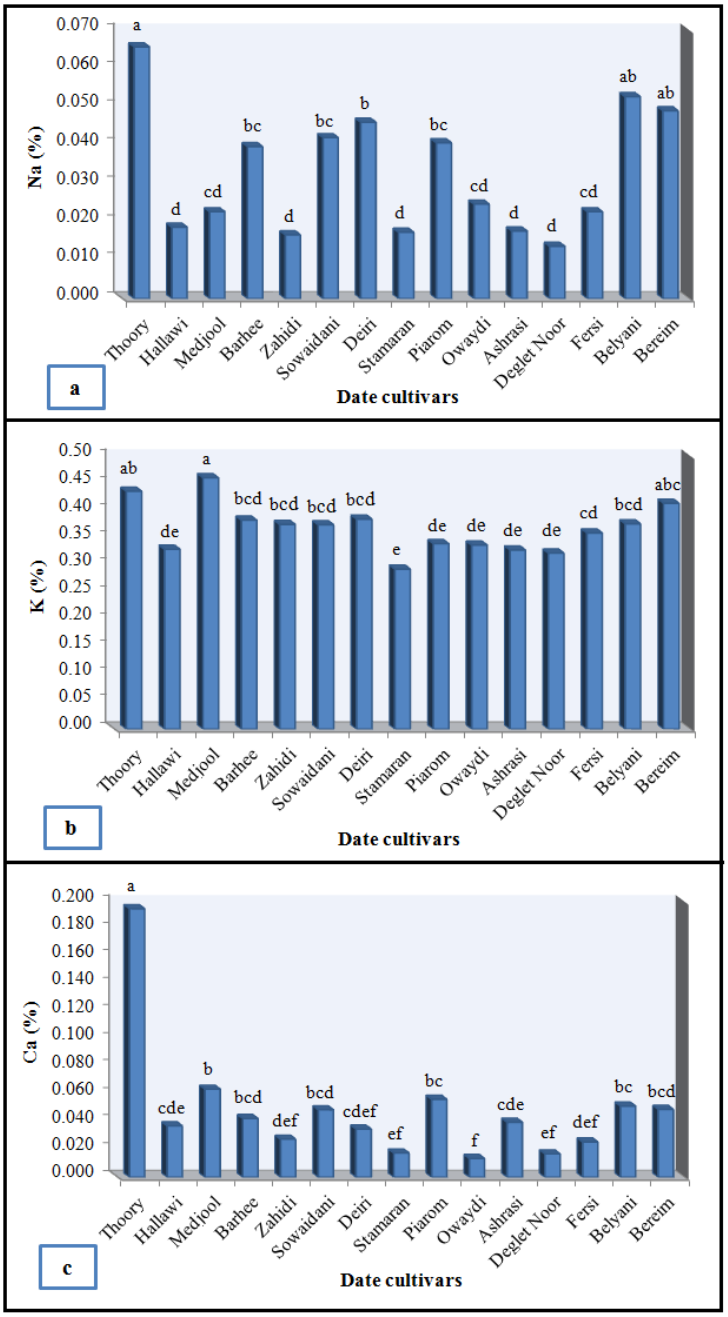

Figure 1- Mean comparisons of macronutrient concentrations [a: Na (%), b: K (%), and c: Ca (%)] in selected date cultivars seed grown in the Ahvaz region of Iran. Means with different letters in each column are significantly different (α=5%), using Duncan's multiple range test

The lowest Zn content was found in the Hallawi cultivar (20.10 $mg.kg^{-1}$). No significant difference was observed between the Zn content in the Hallawi cultivar and the Thoory, Zahidi, Owaydi, and Belyani cultivars. Zinc plays a vital role in cellular membrane structure and function and helps maintain adequate levels of vitamin A in the body [31]. Furthermore, Zn acts as a powerful antioxidant and is essential for tissue growth and development, proper immune function, and insulin regulation [32]. The recommended daily intake of Zn is 11 mg/day [33]. After Zn, Fe was found to be present in considerable amounts in various date cultivars (Table 2). The average amount of Fe in different date varieties was 26.38 and 25.32 $mg.kg^{-1}$, respectively. The difference between the Fe content in the seeds of different date cultivars was minimal. The Fe content in the seeds of different date cultivars ranged from 11.65 to 45.4 $mg.kg^{-1}$. The highest Fe content was observed in the Deiri cultivar, which had a

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significant difference compared to other date varieties. The lowest Fe content was found in the Bereim cultivar, which did not show a significant difference compared to the Fersi and Owaydi cultivars. Iron plays a crucial role in oxygen transport within the body, and Fe deficiency is a major cause of anemia [34]. The recommended daily intake of Fe is 10 mg for men and 15 mg for women. The Deiri cultivar contained the highest amount of Mn in its seeds, and it was significantly different from other cultivars. Additionally, the Zahidi cultivar had the lowest Mn content in its seeds among all date cultivars. However, no significant difference was observed between the Mn content in the Zahidi cultivar and the imported Medjool cultivar, as well as the domestic cultivars of Bereim, Sowaidani, Owaydi, Ashrasi, and Fersi (Table 2). Mn is essential for proper brain function and is involved in protein and carbohydrate metabolism. Mn is required for cholesterol, fatty acids, and collagen formation [35]. Additionally, Mn acts as a blood sugar regulator, activates certain enzymes, and acts as an antioxidant in the human body [36]. The daily human requirement for Mn ranges from 2 to 5 mg [37].

Table 2- Mean comparison of concentrations of micronutrients in the seed of 15 date cultivars in the Ahvaz region of Iran

Cultivar	Fe (mg.kg^{-1})	Mn (mg.kg^{-1})	Cu (mg.kg^{-1})	Zn (mg.kg^{-1})
'Thoory'	23.60^{c}	13.85^{cd}	5.87^{bc}	21.55^{ef}
'Hallawi'	18.50^{cde}	11.97^{cde}	2.40^{e}	20.10^{f}
'Medjool'	33.10^{b}	7.65^{fg}	9.27^{a}	29.90^{b}
'Barhee'	23.85^{c}	14.40^{c}	7.00^{ab}	37.65^{a}
'Zahidi'	18.75^{cde}	7.20^{g}	6.33^{bc}	22.85^{ef}
'Sowaidani'	36.95^{b}	8.45^{efg}	5.93^{bc}	28.85^{bc}
'Deiri'	45.40^{a}	33.00^{a}	6.80^{ab}	24.90^{cde}
'Stamaran'	24.50^{c}	11.75^{cde}	6.77^{ab}	34.10^{a}
'Piarom'	22.20^{cd}	23.05^{b}	6.20^{bc}	25.73^{bcde}
'Owaydi'	12.60^{ef}	7.53^{fg}	5.10^{bcd}	23.30^{def}
'Ashrasi'	20.70^{cd}	7.35^{g}	6.37^{bc}	25.05^{cde}
'Deglet Noor'	35.35^{b}	11.45^{cdef}	7.67^{ab}	26.00^{bcde}
'Fersi'	15.65^{def}	9.10^{efg}	3.87^{cde}	25.05^{cde}
'Belyani'	36.95^{b}	15.05^{c}	2.63^{de}	22.95^{ef}
'Bereim'	11.65^{f}	9.90^{defg}	5.77^{bc}	27.80^{bcd}

Means with similar letter(s) in each column are not significantly different (α=5%), using Duncan's multiple range test

The Cu content in the seeds of different date cultivars studied in Khuzestan province ranged from 2.40 to 9.27 mg.kg^{-1}. The highest Cu content in date seeds belonged to the imported Medjool cultivar, which did not show a significant difference compared to the Barhee, Deiri, Deglet Noor, and Stamaran cultivars. The lowest Cu content was associated with the Halawi cultivar and did not demonstrate a significant difference compared to the Belyani and Fersi cultivars (Table 2). Cu is an essential mineral for maintaining proper organ function and metabolic processes in the human body [38]. The human body requires small amounts of Cu, typically around 100 mg present in the body [39]. Cu accelerates wound healing by increasing blood flow to the injured area and facilitating oxygen movement around the body [40]. The recommended daily intake of Cu ranges from 1.5 to 3 mg/day [41]. The results of this study are consistent with previous research on different date cultivars. In a study conducted on various date cultivars in Saudi Arabia, it was reported that the mineral content in the date seeds, including K (0.363-0.403%), Ca (0.357-0.422%), Na (0.029-0.043%), Fe (124.8-172 µg/g), Mn (17-24.8 µg/g), Zn (3.18-8 µg/g), and Cu (8.8-17.3 µg/g), varies significantly among different date cultivars, which is consistent with our findings [21]. Another study in Saudi Arabia [22] reported that among trace elements, Fe (7.4 mg/100g dry weight) had the highest concentration in date seeds followed by Mn (2.82 mg/100g dry weight), Zn (1.9 mg/100g), and Cu (1.2 mg/100g dry weight), and variations in results may be due to differences in date cultivars, climate conditions,

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and soil type. Habib and Ibrahim [14], in their examination of nutritional elements in the seeds of 18 date cultivars in the United Arab Emirates, stated that K had the highest amount (175.02-240.54 mg/100g of seed powder), which is consistent with our current research. They also reported a descending order of nutritional elements in different date cultivars: Fe (1.32-3.44 mg/100g fresh weight), Zn (1.02-1.63 mg/100g fresh weight), Mn (0.55-1.33 mg/100g fresh weight), Cu (0.14-0.56 mg/100g fresh weight), molybdenum (0.13-0.21 mg/100g fresh weight), and cobalt (0.006-0.0273 mg/100g fresh weight). Bouhlali et al [42], in their study on the seeds of three Moroccan date cultivars, investigated nutritional elements in date seeds and reported K, Na, Mg, Ca, Fe, Cu, Mn, and Zn content as follows: 2967.11-4153.3, 108-319.4, 615.30-827.61, 394.97-626.71, 27.7-70.3, 4.8-8.4, 5.5-10.99, and 8.8-14.8 $mg.kg^{-1}$ dry weight, respectively. They stated that K, Mg, and Ca are the dominant macronutrients, while iron is the dominant micronutrient present in date cultivars. This study demonstrates that date seeds can be utilized in the food, pharmaceuticals, cosmetics industries, and as a dietary supplement to enhance their nutritional value [42]. In another study, it was reported that date seeds contain minerals with concentrations of 2.59-3.59 $g.kg^{-1}$ K, 1.5-47.99 $g.kg^{-1}$ Ca, and 1.33-5.66 $g.kg^{-1}$ P [43].

The correlation matrix provides a symmetric relationship among a large number of traits [44]. The results of the correlation table (Table 3) for the data showed that among different date seeds, the highest positive and significant correlation was observed between the Ca% and Na%. Additionally, Zn% with Cu%, Ca% with K%, and the amounts of Mn with Fe also exhibited a positive and statistically significant correlation compared to other traits. Also, a positive and statistically significant correlation was observed between the amount of Na with the amounts of Mn and K (Table 3). In agreement with our results, a positive and significant correlation has been reported between the amounts of Cu and Zn in different cultivars of dates [45]. The positive correlation between mineral elements indicates that an increase in the concentration of one element is accompanied by an increase in the concentration of another element in date seeds. This relationship can be attributed to common physiological processes or pathways that are involved in the absorption, transport, and accumulation of minerals in dates. Also, the significant and positive correlation among the different traits indicates that the selection of one trait directly influences the expression of another trait, thereby assisting in the selection and advancement of the breeding program. Additionally, Ahmad et al. [46] reported significant positive correlations among phenological and biochemical traits in various cultivars of date fruit.

Table 3- Pearson's correlation coefficients among the investigated traits in the seed of 15 date cultivars in the Ahvaz region of Iran

Traits	Fe	Mn	Cu	Zn	Na	K	Ca
Fe	1						
Mn	0.48**	1					
Cu	0.24	0.04	1				
Zn	0.12	-0.05	0.49**	1			
Na	0.21	0.37*	-0.13	-0.01	1		
K	0.10	0.05	0.24	0.01	0.42**	1	
Ca	0.04	0.10	-0.01	-0.22	0.58**	0.48**	1

* and **: Significant (α= 5%), highly significant (α= 1%), respectively

The hierarchical clustering of micronutrient and macronutrient mineral elements in 15 date seed cultivars using Ward's method is depicted in Figure 2. The date seeds were divided into four clusters. The first cluster consisted of seven cultivars (Thoory, Hallawi, Zahidi, Asharsi, Owaidi, Fersi, and Bereim), which constituted 46.67% of the total cultivars. This cluster had a lower average amount of Fe. However, the average amount of other nutritional elements in

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this cluster was within the moderate range (Table 4). The second cluster included three cultivars (Barhee, Satmaran, and Piarom), which constituted 20% of all cultivars. The seeds of this group, particularly the Barhee and Satmaran cultivars, exhibited high values for Zn and Cu micronutrients (Table 4).

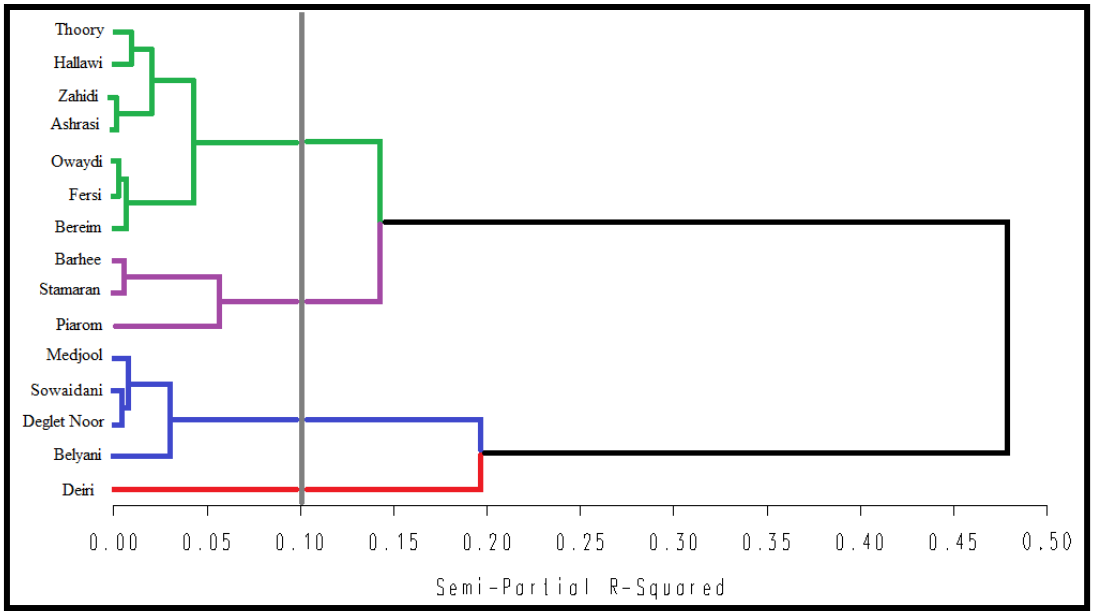

Figure 2- Dendrogram of cluster analysis for micronutrient and macronutrient traits, using Ward's method in 15 date seed cultivars in the Ahvaz region of Iran. The green, purple, blue, and red colors represent the I, II, III, and IV clusters, respectively

In the third cluster, the Medjool, Sowaidani, Deglet Noor and Belyani cultivars were grouped, comprising 26.67% of all cultivars. On average, the seeds of these four date cultivars exhibited a high value for the Fe element. Additionally, the Medjool, Sowaidani, and Deglet Noor cultivars demonstrated a good amount of the Cu element. On average, the K and Zn elements in this cluster were significantly present (Table 4). The fourth cluster only included the Deiri cultivar, whose seed contained a significant amount of Fe, Mn, and Cu micronutrients. Additionally, it exhibited a high nutritional value for Na and K macronutrients (Table 4).

Table 4- Mean values of micronutrient and macronutrient concentrations for date cultivars seed grouped into different clusters in the Ahvaz region of Iran

Traits	Total mean	Cluster I: 7 date cultivars	Cluster II: 3 date cultivars	Cluster III: 4 date cultivars	Cluster IV: 1 date cultivar
Fe concentration ($mg.kg^{-1}$)	25.32	17.35	23.52	35.59	45.40
Mn concentration ($mg.kg^{-1}$)	12.78	9.56	16.40	10.65	33.00
Cu concentration ($mg.kg^{-1}$)	5.86	5.10	6.66	6.38	6.80
Zn concentration ($mg.kg^{-1}$)	26.39	23.67	32.49	26.93	24.90
Na concentration (%)	0.03	0.03	0.03	0.03	0.05
K concentration (%)	0.37	0.37	0.34	0.38	0.38
Ca concentration (%)	0.05	0.06	0.04	0.05	0.04

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Micronutrient deficiency is a significant problem in the field of public health in many developing countries. This issue is particularly critical for infants and pregnant women, as they require adequate amounts of micronutrients for healthy growth and development [47, 48]. Having comprehensive information about micronutrients can encourage food manufacturers to incorporate date palm seed flour in fortifying their products [42]. Research conducted both domestically and internationally has also emphasized the potential of utilizing date seed waste in the food industry and factories. The studies conducted by Moeenfard et al. [49] have shown that the preparation method and the type of variety used to prepare date seed drink have a significant effect on its chemical and physical properties. Additionally, date seed extract can play an important role in the treatment of AIDS [50]. Based on the conducted research, date seed extract demonstrates a relatively strong inhibitory effect against bacterial growth due to the presence of phenolic compounds such as gallic acid, ascorbic acid, and caffeic acid [51, 52]. Date seed powder is successfully utilized in the production of various food products, including chocolates, cakes, beverages, and bakery products [12, 53]. Hajizadeh et al. [54] have stated that adding date seed flour to cake formulations can be a suitable option for enriching gluten-free cakes due to its high nutritional value. Therefore, the use of this cost-effective ingredient is important for increasing the added value of date-based products and for combining it with various food products in the industry.

4- Conclusion

In general, the amount of micronutrients in the seeds of different cultivars of dates, examined in the present study, exhibited significant variations, to the extent that the amount of certain nutritional elements in the seed of one date cultivar was several times higher than that of other cultivars. Therefore, in order to enrich food products with a specific nutrient, the seed powder of a particular date cultivar, which possesses a high nutrient content, can be utilized in the food processing industry. Based on the results, the seeds of the native date cultivars Deiri and Barhee, as well as the imported cultivar Medjool, exhibited a significant amount of nutrients. Considering the dominant mineral composition in these seeds, they can be effectively utilized in the formulation of food products within the country. Moreover, the seeds of Medjool and Zahidi dates demonstrated low Na and high K content, which can be beneficial for individuals suffering from high blood pressure.

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مقایسه میزان عناصر غذایی در هسته ارقام مختلف خرمای داخلی و خارجی

محمدرضا پورقیومی[۱]، کمال غلامی‌پور فرد[۲]، سارا فرخ‌زاده[۳*]

۱- محمدرضا پورقیومی، استادیار پژوهشی، پژوهشکده خرما و میوه‌های گرمسیری، موسسه تحقیقات علوم باغبانی، سازمان تحقیقات، آموزش و ترویج کشاورزی، اهواز، ایران.

۲- کمال غلامی‌پور فرد، استادیار، بخش تولیدات گیاهی، دانشکده کشاورزی و منابع طبیعی داراب، دانشگاه شیراز، داراب، ایران.

*۳- سارا فرخ‌زاده، دکتری اصلاح نباتات، بخش تحقیقات زراعی و باغی، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان فارس، سازمان تحقیقات، آموزش و ترویج کشاورزی، شیراز، ایران.

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مسئول مکاتبات: *

Sfarokhzadeh87@gmail.com

چکیده

هسته خرما منبعی غنی از مواد معدنی، فیبر، کربوهیدارت و دارای ترکیبات آنتی‌اکسیدانی بالایی است که می‌تواند به‌عنوان یک منبع ارزان و فراسودمند در فرمولاسیون محصولات غذایی در کشور مورد استفاده قرار گیرد. این پژوهش به منظور بررسی میزان عناصر غذایی در هسته ۱۵ رقم خرمای تحت کشت در استان خوزستان شامل ارقام داخلی (فرسی، استعمران، زاهدی، دیری، بلیانی، بریم، برحی، سویدانی، اشرسی، حلاوی، عویدی و پیارم) و خارجی (مجول، دگلت‌نور، توری) در پژوهشکده خرما و میوه‌های گرمسیری انجام شد. این ارقام در قالب طرح کاملاً تصادفی با سه تکرار مورد تجزیه و تحلیل قرار گرفتند. نتایج نشان داد که بین میزان مواد معدنی هسته ارقام مختلف خرمای مورد بررسی، تفاوت بسیار معنی‌داری از نظر میزان عناصر معدنی آهن، منگنز، مس، روی، سدیم، پتاسیم و کلسیم وجود دارد. در هسته‌های خرما، عنصر پتاسیم دارای بالاترین مقدار نسبت به سایر عناصر بود و پس از آن کلسیم، سدیم، روی، آهن، منگنز و مس قرار گرفتند. بالاترین میزان عناصر آهن و منگنز در هسته رقم دیری و بالاترین میزان مس و پتاسیم در هسته رقم مجول مشاهد شد. هسته رقم دگلت‌نور داری بالاترین میزان سدیم و کلسیم بود. همچنین، بالاترین میزان عنصر روی در هسته رقم برحی یافت شد. در هسته‌های ارقام مختلف خرما، بین درصد کلسیم و درصد سدیم بیشترین همبستگی مثبت و معنی‌دار مشاهده شد. بر اساس نتایج تجزیه خوشه‌ای، ارقام خرمای مورد بررسی از نظر میزان عناصر غذایی هسته، در چهار گروه اصلی طبقه‌بندی شدند. به‌طور کلی، هسته‌های خرمای ارقام مورد بررسی، حاوی مقادیر قابل توجه اما کاملا متغیری از عناصر غذایی بودند و استفاده از هسته‌های ارقام خرمای داخلی دیری و برحی و رقم خارجی مجول به‌عنوان اجزای مهم در تولید مواد غذایی فراسودمند در کشور توصیه می‌شود.

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