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Chemical Composition and Nutritional Value of Palm Pollen Grains

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Abstract: The objective of the study was to determine the chemical composition and nutritional value of palm pollen grains. The proximate chemical composition, vitamin, mineral, amino acid and fatty acid contents of palm pollen grains were analyzed. The results obtained showed that the values of the proximate chemical composition of palm pollen grains were moisture (28.80%), ash (4.57%), crude fiber (1.37%), crude fat (20.74%), crude protein (31.11%) and carbohydrate (13.41%). Palm pollen grains contained a logical amount of vitamins A, E and C. They are a good source of minerals such as B, Zn, Se, Fe, Mo, Cu, Mn, Co and Ni. Leucine and lysine (3.34 and 2.95 g/100 g dry weight, respectively) were the major essential amino acid constituents. The predominant fatty acids of palm pollen grains were palmitic (C16:0), linoleic (C18:2) and myristic (C14:0) acids. In conclusion, palm pollen grains are a good economic nutritional source can be used as human food supplements.

Key words: Palm pollen grains · Chemical composition · Nutritional value · Vitamins · Minerals · Amino acids · Fatty acids.

INTRODUCTION

Pollens are the male reproductive cells of flowers. Most noncultivated plants produce pollens. The early Egyptians and ancient Chinese used pollen as a rejuvenating medicinal agent. It has been called a "fountain of youth". Pollen preparations are distributed worldwide for dietary purposes and as diet supplement by increasing the total dietary intake [1]. On the other hand, date palm (*Phoenix dactylifera* L. family Palmae) pollens are commonly used in the Middle East, especially in Egypt. Suspension of date palm pollen is an herbal mixture that is widely used as a folk remedy for curing male infertility in traditional medicine. Egyptian scientists have reported the gonad stimulating potency of date palm pollen. Pollen grains of date palm were also used to promote fertility in women in ancient Egypt [2, 3].

Chemical composition of pollens is considerably varied between plant species. For example, pollens of pine (*Pinus radiate* D. Don), corn (*Zea mays* L.) and bulrush (*Typha latifolia* L.) contain 13.92; 36.59; and 31.93% total carbohydrates, 0.05; 6.88; and 0.04% reducing sugars, 11.45; 7.31; and 18.88% non-reducing sugars, 2.42; 22.40; and 13.01% starch, 13.45; 20.32; and 18.90% proteins, 1.80; 3.67; and 1.16% lipids and 2.35; 4.90; and 3.80% total ash, respectively. Chemical composition of pollens is also varied with the conditions of handling and storage and is related to germinating ability [4]. In general, bee-collected pollens contain nutritionally essential substances like carbohydrates, proteins, amino acids, lipids, vitamins, mineral substances and trace elements, but also significant amounts of polyphenol substances mainly flavonoids [5-12]. Bee-pollen is promoted as a health food with a wide range of nutritional and therapeutic properties [13-18].

Regarding the chemical composition of date palm (*Phoenix dactylifera* L.) pollens, the literature was poor concerning in the data of chemical composition of these pollens. El-Ridi *et al.* [19] isolated a yellow water-soluble flavone pigment from the pollen grain of date palm. Chemical and spectroscopic investigations of this pigment have shown that it is identical with pure rutin. Stanley and Linskens [4] mentioned that palm pollens contain 1.20% total carbohydrates, 1.07% reducing sugars, 0.13% non-reducing sugars and 6.36% total ash. In contrast to all other plant pollens, date palm pollens do not contain starch. Phytochemical screening showed that dried date palm pollens contain sterols, triterpenes, saponins, proteins, carbohydrates and (or) glycosides and lacked volatile substances [20]. Several steroids, including the brassinosteroid (24-epi-castasterone), were isolated from date palm pollen grains and identified by

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GC-MS [21]. Bacha *et al.* [22] conducted a study on the chemical composition of pollen grains from 13 cultivars of date palm males grown in Deirab, Saudi Arabia. The chemical analysis revealed differences among cultivars. The average concentrations of moisture, ash, lipids and proteins in pollen were 3.6-4.8, 4.7-7.1, 0.8-1.8 and 15.8-18.0%, respectively. Carbohydrate content ranged from 10.5 to 13.1%. Mineral content of pollen grains also differed from one cultivar to another. The macronutrients, N was present in the highest concentrations, followed by Ca, P, Mg and Na, while the micronutrients, Fe was present in the highest concentrations, followed by Zn, Mn and Cu. Contrary to that mentioned by Stanley and Linskens [4], Bacha *et al.* [22] mentioned that pollen grains of date palm males contain starch. Starch content ranged from 8.1 to 9.2% and represented 75% of the total carbohydrates.

The aim of this study was to investigate the chemical composition and nutritional value of palm pollen grains.

MATERIALS AND METHODS

Materials

Plant Material: Pollen grains of Egyptian date palm (*Phoenix dactylifera* L. variety El-Hayani) were collected at the end of March from Shabramant, Giza, Egypt.

Methods

Proximate Chemical Analysis: Palm pollen grains were analyzed for chemical composition using the following official methods. Moisture and crude fat contents were determined according to AOAC [23]. Ash content was determined according to AOAC [24]. Crude fiber content was determined according to AOAC [25]. Total nitrogen content was determined by micro-Kjeldahl method according to AOAC [26]. The crude protein content was calculated by multiplying the total organic nitrogen by 6.25. Carbohydrate content was determined as total hydrolysable carbohydrate by the phenol-sulfuric method as described by Dubois *et al.* [27].

Vitamin Analysis: Vitamin C content of palm pollen grains was determined using the method described by Bajaj and Kour [28]. Vitamin A and E contents of palm pollen grains were determined using the methods described by Hawk *et al.* [29].

Mineral Analysis: The minerals B, Zn, Se, Fe, Mo, Cu, Mn, Co and Ni were determined after digestion the sample by advanced microwave digestion system (ETHOS 1, USA). The minerals were measured by ICP spectrometer thermo scientific (iCAP 6000 series, England).

Amino Acid Analysis: Amino acids composition was analyzed by automatic amino acid analyzer (AAA 400 INGOS Ltd. Czech Republic). The sample (100 mg) was hydrolyzed with 10 ml of 6*M* HCl in a sealed tube at 110°C in an oven for 24 h. After hydrolysis, the acid was evaporated in a vacuum evaporator under reduced pressure at 80°C. The HCl free residue was dissolved in 2 ml of loading buffer (0.2 *M*, pH 2.2) to inject into the apparatus [30].

Fatty Acid Analysis: Fatty acid composition was analyzed by gas chromatography according to the method described by Farag *et al.* [31]. Fatty acid methyl esters were fractionated using GC apparatus (TRACE GC Ultra, USA) equipped with a flame ionization detector. The temperatures of the injector and detector were 200 and 220°C, respectively. Separation was achieved on a 30 m × 0.25 μm TR-FAME capillary column coated with a 0.25 μm film. Nitrogen was used as carrier gas at 30 ml/min. The column temperature was 140°C then programmed to increase to 200°C at a rate of 5°C/min and then held for 3 min. All analyses were performed in triplicates.

RESULTS AND DISSCUSION

Chemical Analysis: Chemical analysis of pollens has revealed the presence of a wide range of biochemically and nutritionally important substances: minerals, trace elements, a wide range of carbohydrates, organic acids, lipids, sterols, nucleic acids, proteins, free amino acids as well as water and lipid-soluble vitamins, as well as over 100 different kinds of enzymes and cofactors [4, 32, 33].

Proximate Chemical Composition: In this study, palm pollen grains (var. El-Hayani) were analyzed for their constituents of moisture, ash, crude fiber, crude fat, crude protein and carbohydrate. The obtained data are given in Table 1 indicated that moisture content of palm pollen grains was 28.80%. This value was higher than the values (3.6-4.8%) obtained by Bacha *et al.* [22] and within the values (20-30%) obtained by Stanley and Linskens [4] and Bell *et al.* [34]. Values of 4.57 and 1.37% were estimated for ash and crude fiber contents, respectively. These values are comparable to those reported by Human and Nicolson [8], Bacha *et al.* [22], Bell *et al.* [34] and Herbert and Shimanuki [35] who found that the ash of pollen ranged from 0.9 % and 6.4%. Crude fiber content of pollen ranges from 0.3-20%. Crude fat content value of palm pollen grains was 20.74%. This value was higher than the values (0.8-1.8%) obtained by Bacha *et al.* [22]. The value of crude fat content was within the values (0.8-31.7%)

Table 1: Proximate chemical composition (g/100 g dry weight) of palm pollen grains

Parameter	Palm pollen grains
Moisture (%)	28.80
Ash (%)	4.57
Crude fiber (%)	1.37
Crude fat	20.74
Crude protein (%)	31.11
Carbohydrate (%)	13.41

Values are means of three replicates.

Table 2: Vitamin composition of palm pollen grains

Vitamin	Palm pollen grains
A (IU/100 g)	7708.33
E (IU/100 g)	3030.92
C (mg/100 g)	89.09

Values are means of three replicates.

obtained by Farag *et al.* [36], Evans *et al.* [37] and Roulston and Cane [38]. The latter study recorded lipid content higher than 5% for at least 60% of the plant species. Crude protein content value of palm pollen grains was 31.11%. This value was higher than the values (15.8-18.0%) obtained by Bacha *et al.* [22]. The value of crude protein content was within the values (12-61%) obtained by Human and Nicolson [8] and Roulston *et al.* [39]. Also, Campos *et al.* [10] reported that protein content of pollen ranges between 10-40 g/100 g dry weight. The value obtained for carbohydrate content was 13.41%. This value was within the range estimated by Stanley and Linskens [4], Margaoan *et al.* [12] Bacha *et al.* [22]; Szczesna *et al.* [40] and Bogdanov [41]. Variations in the chemical composition of palm pollen (var. El-Hayani) and other pollens reflect differences in species, environmental conditions during maturation and age and vigor of the plants [42, 43].

Vitamin Composition: The content of some vitamins in palm pollen grains is shown in Table 2. Data showed that palm pollen grains contain a logical amounts of vitamins A, E (7708.33 and 3030.92 IU/100 g, respectively) and C (89.09 mg/100 g). The amount of vitamin A was higher than the amount of vitamin E in palm pollen grains. The β-carotene constitutes the principle source of provitamin A is of vital importance for vision, bone growth and reproduction. The β-carotene content of pollen ranges between 10-200 mg/kg [44, 45]. The average value of vitamin E in bee-collected pollen was 320 μg/g pollen fat and the vitamin E content of pollen ranges between 40-320 mg/kg [4, 45]. Vitamin C or ascorbic acid occurs in relatively high levels in pine and palm pollens [4]. Ascorbic acid content of bee-collected pollen ranges between 70-560 mg/kg [10, 45].

Table 3: Mineral composition (mg/100 g dry weight) of palm pollen grains

Mineral	Palm pollen grains
Boron (B)	309.4
Zinc (Zn)	281.0
Selenium (Se)	305.0
Iron (Fe)	241.0
Molybdenum (Mo)	302.2
Copper (Cu)	319.6
Manganese (Mn)	284.0
Cobalt (Co)	305.4
Nickel (Ni)	302.4

Values are means of three replicates.

Mineral Composition: The mineral composition of palm pollen grains is shown in Table 3. The obtained results revealed that palm pollen grains constitute a rich source of mineral elements. The predominant minerals were copper (319.6 mg/100g), followed by boron (309.4 mg/100 g), cobalt (305.4 mg/100 g) and selenium (305 mg/100 g). Equal amounts of nickel and molybdenum (302.4 and 302.2 mg/100 g, respectively) were found in palm pollen grains. Palm pollens also contain useful amounts of manganese (284 mg/100 g), zinc (281 mg/100 g) and iron (241 mg/100 g). According to Stanley and Linskens [4] pointed that date palm pollen (*Phoenix dactylifera*) is particularly high mineral content. This may be related to the high mineral content of the soil horizons in dry areas where this species grows. But, the capacity of the parent plant to accumulate salts in the pollen is also related to the species. Bacha *et al.* [22] found that pollen grains of date palm contain the macronutrients, N was present in the highest concentrations, followed by Ca, P, Mg and Na. Of the micronutrients, Fe was present in the highest concentrations, followed by Zn, Mn and Cu.

Variations in the mineral composition of palm pollen and other pollens reflect the differences in the floral origin of pollen and the plant growth conditions, such as soil and geographic origin [42]. According to Stanley and Linskens [4] stated that there are differences in the mineral content of pollen collected by bees and pollen collected directly from the flower. However, mineral levels vary with species and sources of error may arise because different colorimetric or qualitative analytical methods are used, or because some elements such as boron or chlorine may be volatilized by certain ashing conditions and not by others. Results are sometimes reported as precent fresh weight but generally they are recorded as percent of dry weight or percent of total pollen ash.

Table 4: Amino acid composition (g/100 g dry weight) of palm pollen grains

Amino acid	Palm pollen grains
Essential amino acids	
Isoleucine (Ile)	1.49
Leucine (Leu)	3.34
Lysine (Lys)	2.95
Phenylalanine (Phe)	1.63
Threonine (Thr)	1.72
Valine (Val)	1.81
Hisitidine (His)	1.61
Methionine (Met)	0.11
Nonessential amino acids	
Alanine (Ala)	2.61
Arginine (Arg)	1.61
Aspartic acid (Asp)	3.55
Glutamic acid (Glu)	1.74
Glycine (Gly)	2.24
Serine (Ser)	1.89
Cysteine (Cys)	0.42
Tyrosine (Tyr)	1.55
Proline (Pro)	0.28
Ammonia	0.45
Total amino acids	30.55

Values are means of three replicates

Table 5: Fatty acid composition (%) of palm pollen grains

Fatty acid	Palm pollen grains
Capric acid (C10:0)	0.46
Lauric acid (C12:0)	4.82
Myristic acid (C14:0)	13.33
Palmitic acid (C16:0)	34.45
Stearic acid (C18:0)	2.04
Arachidic acid (C20:0)	7.32
Total SFA	62.42
Palmitoleic acid (C16:1n-7)	7.07
Oleic acid (C18:1n-9)	7.19
Total MUFA	14.26
Linoleic acid (C18:2)	14.24
α-Linolenic acid (C18:3n-3)	0.79
γ-Linolenic acid (C18:3n-6)	1.27
Arachidonic acid (C20:4n-6)	4.57
Eicosapentaenoic acid (C20:5n-3)	0.52
Total PUFA	21.39
Unidentified peak a	0.24
Unidentified peak b	0.25
Unidentified peak c	1.44
Total unidentified peaks	1.93
Total fatty acids	100

Values are means of three replicates.

Amino Acid Composition: Amino acid composition may define the nutritional value of pollen more accurately than protein content, since the nutritional value is reduced when inadequate amounts of the essential amino acids are present [46,47]. Generally, pollen contains all the essential amino acids but the amounts may vary between plant species [39]. In the present study, palm pollen grains were analyzed for their contents of 17 of the most quantitatively important amino acids. Data obtained are given in Table 4 showed that palm pollen grains contained 8 essential amino acids and 9 nonessential amino acids. The major essential amino acids of palm pollen grains were leucine and lysine (3.34 and 2.95 g/100 g dry weight, respectively). Moderate amounts of essential amino acids were observed in palm pollen grains. These amino acids were valine, threonine, phenylalanine, histidine and isoleucine, since it was recorded 1.81, 1.72, 1.63, 1.61 and 1.49 g/100 g dry weight, respectively. Methionine was considered limited essential amino acid in palm pollen grains and recorded 0.11 g/100 g dry weight. In respect of nonessential amino acids, aspartic acid, alanine and glycine were considered the major amino acids of palm pollen grains (3.55, 2.61 and 2.24 g/100 g dry weight). Moderate amounts of serine, glutamic acid, arginine and tyrosine were seen in the palm pollen grains and recorded 1.89, 1.74, 1.61 and 1.55 g/100 g dry weight, respectively. On the other hand, the contents of palm pollen grains of cysteine and proline were limited. The values reached 0.42 and 0.28 g/100 g dry weight, respectively. Total amino acid and ammonia contents of palm pollen grains were recorded 30.55 and 0.45 g/100 g dry weight, respectively. Analyses have shown that all the essential amino acids are present in pollen. Generally in most pollen 2 to 5 amino acids constitute over 50% of the protein weight. The other 50% of the proteins are generally built from the remaining 15 to 18 common amino acids [4, 48]. Seventeen different amino acids may be present in pollen loads Proline, glutamic and aspartic acids, lysine and leucine are the predominant amino acids, constituting approximately 55% of total amino acids [10, 49]. The amino acid content and total nitrogen can vary with the climatic and nutritional conditions of the plants on which the pollen matures [4].

Fatty Acid Composition: In addition to variation in lipid content, pollen also varies in the relative proportions of fatty acids as well as in their diversity [6]. Data showed that the lipid fraction of palm pollen grains includes 13 fatty acids and a number of minor unidentified peaks (Table 5). In general, the predominant fatty acids of palm pollen grains were palmitic (C16:0), linoleic (C18:2) and

myristic (C14:0) acids. The saturated fatty acids (SFA) identified included capric, lauric, myristic, palmitic, stearic and arachidic acids. It was recorded 0.46, 4.82, 13.33, 34.45, 2.04 and 7.32%, respectively. Palmitoleic and oleic acids as monounsaturated fatty acids (MUFA) compose 14.26% of lipid content found in palm pollen grains. The polyunsaturated fatty acids (PUFA) identified included linoleic, α-linolenic, γ-linolenic, arachidonic, eicosapentaenoic acids. These five fatty acids compose 21.39% of lipid content of palm pollen grains. In general, the dominant fatty acids present in pollens are palmitic (C16:0), oleic (C18:1), linoleic (C18:2) and linolenic (C18:3) acids [4, 50]. Bastos *et al.* [6] also found oleic, linoleic, araquidic and palmitic acids, 19-56% total unsaturated acids.

Finally, many factors can influence the kinds and proportions of these different chemical substances in pollen including the species of the plant, where the plant is grown, the season of the year collected and even the time of day the pollen is collected [4,32].

CONCLUSION

Finally, it could be concluded that palm pollen grains are a good economic nutritional source can be used as human food supplements.

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