

REVIEW

Date palm and sandstorm-borne allergens

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Introduction

The date palm (*Phoenix dactylifera* L) is one of the most important plants and has for centuries seen several uses by people in all continents of the world. The earliest archaeological finds dated 5000–6000 BC were from Iran, Egypt and Pakistan. It was naturalized in Arabia and spread through Northern Africa, into Spain, throughout the drier parts of the Nile valley and around the Euphrates River. From Spain it was introduced to America, where it is now grown commercially in the warm valleys of Southern California and Arizona. Dates are cultivated throughout the desert regions of the world and grow well between latitudes 15° and 35°N [1, 2].

Dates are a commercial crop but date trees are also grown on family compounds, along streets and highways, and are seen in every conceivable space in Saudi Arabia and parts of the Middle East. They are cultivated in the southern parts of Italy, Spain and Australia.

The date palm belongs to the class Monocotyledoneae, subclass Areciae and is a member of the family Arecaceae (formerly Palmaceae). Date palms are dioecious but male and female plants look alike (Fig. 1a). Both male (pistillate; Fig. 1b) and female (staminate; Fig. 1c) inflorescences are branched and are enclosed by sheathing fibrous spathes. The heterozygous nature of the palm due to its dioecious habit and the long period of cultivation have led to the establishment of thousands of different types of date cultivars (Fig. 1d). In Saudi Arabia, about 100 different fruit cultivars are sold at local markets during harvest and 350 cultivars of soft dates are estimated to exist in the Basra region of Iraq alone [3]. The fruits are a constituent of hundreds of foods and condiments (Figs 1e and f).

Dates palms flower from February to April and are pollinated during these months. Pollen production is so prolific that pollen from one male plant is sufficient to pollinate 50–100 female date trees. The male palms produce between 30 and 50 inflorescences yearly. Typical pollen is light and small and measures about 8×25 microns in size (Fig. 2). Date pollen is unique in morphology and only slightly resembles pollen of *Sabal palmetto* and *Ginkgo biloba*. Date pollination should be naturally anemophilous (wind-pollinated) with a little contribution from visiting insects, birds and rodents. However, in order to effect efficient fertilization and to maximize fruit yield, this method has been largely replaced by hand pollination or mechanical spraying of pollen. During pollination, a great deal of date pollen is inadvertently released into the atmosphere and dispersed by wind. Due to the large quantities of pollen

used for pollination, much pollen is also left between the branches, bracts and other parts of the plant [4]. In Saudi Arabia, the situation is made more complex by the fact that it rarely rains and the residual pollen does not get washed off, but remains airborne for several months, serving as a useful perennial sensitizing source for predisposed individuals. Some pollen also remains on the gynoecium until fruits are set. Date fruits become sticky on ripening and the residual pollen gets stuck on the outside of the fruits until harvest and later consumption.

Even though date fruits are eaten worldwide and are a component of several items in health food shops and on supermarkets shelves all over the world (Figs 1e and f), they are not seen and considered as important in other parts of the world as they are in the Middle Eastern and North African countries, where they form part of the daily diet.

It is common knowledge amongst inhabitants of Saudi Arabia that date pollen is a causative agent of asthma and seasonal allergic rhinitis. They also know that some varieties or cultivars of date fruits, on consumption may cause severe rhinitis as well as itching of the mouth and cases of urticaria, angio-oedema and anaphylaxis have occurred [5]. These episodes and a recent case of anaphylaxis in France [6] have confirmed an isolated case of immediate hypersensitivity in a non-atopic patient in Spain [7]. The importance of the probable allergenic effects of date pollen and fruits observed by the local people is underscored by the fact that some clinicians in allergy clinics in Saudi Arabia, through patient request, found it necessary to obtain 'custom-made date extracts' from commercial sources abroad for inclusion in their allergy skin prick test (SPT) panel [4, 8].

In spite of these observations and concerns, there were no comprehensive published references made to date palm allergens until just over a decade ago. The allergenic potential of the date palm pollen and fruits has been investigated and date peptides are now considered potent allergens [4, 9–13].

The causes of most atopic diseases are multifactorial and it has been well documented that several environmental factors play a role in their manifestation. Changes in meteorological conditions, notably those caused by thunderstorms, and certain industrial activities, such as unloading of cargo ships at harbours, have been known to cause epidemics of asthma and exacerbate other respiratory ailments in susceptible individuals [14–19].

Allergic diseases are among the most common diseases in the world and numerous epidemiological studies have demonstrated a steady and significant increase in worldwide prevalence in the last two decades [20–25]. Reports from different parts of the world indicate an escalation in the incidence of hay fever, asthma, atopic eczema and food allergies [26]. Similar studies carried out in various parts of the Middle East such as Turkey and Kuwait have all confirmed this trend [24, 27].

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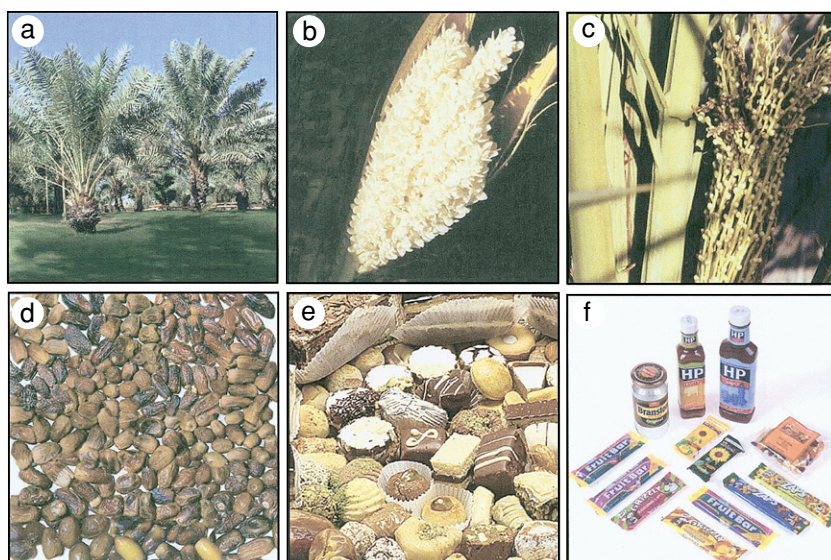


Fig. 1. Reproductive and vegetative parts, fruits and some edible date products: (a) young date palm trees on a residential compound; (b) male inflorescence bearing mature pollen ready for pollination; (c) mature female inflorescence; (d) a mixture of ripe date fruits from 20 different cultivars; (e) a selection of sweets, cakes and other date-containing foods; (f) a selection of common date-containing items from health food shops and supermarkets.



Fig. 2. Scanning electromicrograph of a single pollen measuring $22 \times 12 \mu\text{m}$. Typical date pollen surface architecture showing rudiments of the exine are seen.

It is obvious from the literature that studies on the most characterized allergens have been carried out in areas where these allergens occur and pose a potential health threat to the inhabitants. Date palms are indigenous to Saudi Arabia and neighbouring countries and sandstorms affect the whole of the Middle Eastern and the Arabian Gulf countries. The aims of this manuscript are to (i) review current knowledge on date palm pollen and fruit allergy and (ii) highlight how sandstorms and other biotic and abiotic factors act in concert to pose a public health hazard for allergy and asthma sufferers, and the population as a whole.

Allergy to date palm pollen

The antigenic and allergenic potential of date palm (*P. dactylifera* L) peptides was a much-neglected topic until recently. Even though the date palm is mentioned in some old books on allergenic plants [28, 29], it was only just over a decade ago

that the allergenic potential of date pollen and fruits was investigated by *in vivo* and *in vitro* methods [4, 5, 9, 30–35]. Date palm pollen extracts and their purified fractions are now known to possess allergens that contain IgE and IgG antibodies in sera from patients with date palm allergy. These extracts and their fractions are capable of inducing skin test responses in sensitized individuals. Results of the maiden study carried out in Saudi Arabia on an atopic population attending an outpatients' allergy clinic at King Faisal Specialist Hospital and Research Centre (a tertiary referral hospital with a large catchment area including the Gulf states) have indicated by SPT that about 25% of the atopic population tested were sensitized [4]. Waisel et al. used date pollen extracts and skin prick tests SPT to investigate responses in 705 allergic patients in Israel and concluded that sensitivity to date and pecan pollen was much higher among residents of rural than of urban communities [36].

It is not clear how different species of the genus *Phoenix* are antigenically or allergenically related but allergic sensitization to *P. canariensis* and *P. sylvestris* have also been reported [37, 38]. Chakraborty et al. reported a 44% positive SPT in 540 respiratory allergic patients studied, and Chowdhury et al. reported similar SPT reactivity to palm pollen [13, 38]. Investigations carried out by Kwaasi et al. [4, 8, 9, 30–35] in which various *in vivo* and *in vitro* methods were used have shed some light on the allergenicity of date pollen: in radioallergosorbent assay (RAST), IgE-based enzyme-linked immunosorbent assay (ELISA) and lymphocyte proliferative assay using different batches of whole extracts and fractions, stronger positive reactions were evoked in atopic subjects than in normal individuals [4, 5, 8, 9, 30–35]. The major IgE-binding components (major allergens) of date palm pollen have been determined by ELISA and western blotting. Kwaasi et al. used a pool of purified allergenic fractions and sera from skin test-positive atopic individuals and constructed an allergogram. Six components of ≤ 12 , 14, 28–30, 37–40, 57 and 65–67 kDa bound IgE in 60–93% of atopic sera (Fig. 3). Their results clearly demonstrated that date pollen has six major allergens of the above molecular weight range and have been assigned the notations 'Pho d 1' to 'Pho d 6' in the order listed [8].

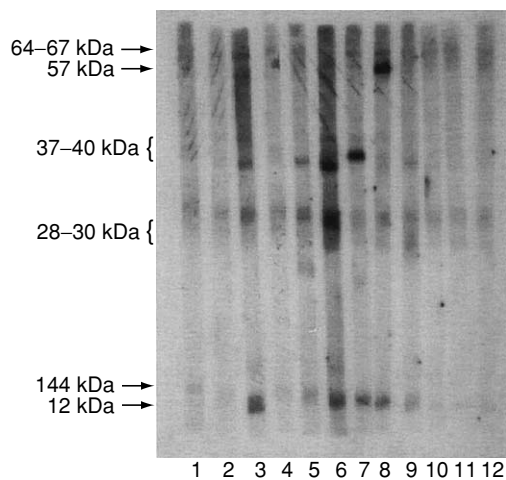


Fig. 3. Typical IgE immunoblots of date pollen extracts with 12 individual atopic human sera. Radio-iodinated anti-human IgE was used to detect IgE-binding components in atopic human sera. Arrows point at the major date pollen allergens Pho d 1 to Pho d 6.

Fernandez et al. in a recent study reported the use of a biologically standardized extract to determine the relevant IgE-binding proteins [11]. Unfortunately, no information was given about the results of SPT, but they described proteins of molecular masses 6, 14 and 18 kDa as the major allergens. Chakraborty et al. reported that the major allergens of *P. sylvestris* were components of 33 and 60 kDa [38]. The number of major allergens identified by Chakraborty et al. and Fernandez et al. [11] are fewer than those previously reported by Kwaasi et al. [4, 8], however, there is agreement on the molecular weights ranges of some of the major allergens reported by all three investigators.

Antigens and allergens of date fruits

Date fruit extracts have been evaluated in SPTs, used in producing antisera, analysed by sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE), fractionated by gel filtration chromatography and tested by ELISA, RAST and IgG and IgE immunoblot experiments. About 13% (23/178) of patients presenting with allergic rhinitis and/or extrinsic asthma were SPT-positive to some extracts and the numbers are growing [5, 33]. IgE immunoblots of different extracts with pooled positive sera revealed between three and nine IgE-binding date fruit-reactive bands per extract. An allergogram showed conclusively that all (100%) positive sera from date fruit- and pollen-allergic individuals bound strongly to two fused IgE-reactive bands of 6.5–14 kDa and 28–33 kDa and about 50% of sera bound to a 54–58 kDa peptide band, these being the date fruit major allergens. It has therefore been proposed that these three major allergens of the date fruit are assigned the notations Pho d f1, Pho d f2 and Pho d f3 in the order indicated; the 'f' to indicate fruit [33].

Differential antigenic and allergenic properties of pollen and fruits from different date palm cultivars

Variability of antigens and allergens from different varieties, strains, serotypes or pathotypes of the same species has been

well documented for some viruses, fungi, Rhizopoda, insects, bacteria, olives and bell peppers [39–49]. There is evidence that pollen of *Holoptera integrifolia* collected from different ecozones of India varies in IgE-binding proteins [50] and Chaudhry et al. [51] further reported that there are shared as well as male- and female-specific antigens and allergens of the American cockroach (*Periplaneta americana*). It has also been shown that even horse epithelia differ in their physicochemical and immunochemical characteristics, depending on the strain or source material [52].

Antigenic and allergenic differences between cultivars and varieties of several allergenic material from diverse environments have been reported: for example, olive has been studied by several workers [53–55], allergenicity of peanuts has been looked at for its high oleic content [56] and also in cultivars bred in different parts of the world for their major allergen content [57]. Aplin and Lovell have looked at the cultivar involvement of *Primula* and concluded that six main species were responsible for cutaneous reactions in patients [58]. Hausen et al. investigated orchid cultivars of the genus *Cymbidium* and were successful in establishing that contact allergy in this genus and in more than 50 different plant species was due to sensitization by a benzoquinone [59]. Allergy due to *Alstrumelia* cultivars has also been looked at by de Groot et al., and Hausen and Helmke have investigated cultivars of marigold. In all these allergenicity due to intercultural differences were established [60, 61].

It is therefore well-established that allergenic materials from different ecological sources or from different breeds, strains, cultivars or horticulture varieties could be differentially allergenic. The most salient point to be addressed when a novel allergen or any disease-causing agent, whether organismal, particulate or molecular is identified is to be able to establish its *in vivo* as well as *in vitro* role. Allergenicity is complex and can be even more so when the plant being investigated has hundreds of cultivars and grows in a number of diverse ecological niches.

The allergenic potential of date pollen and fruits has been investigated. Due to the complex nature of atopic diseases attempts were made to investigate as many parameters that could reflect these differences as possible, namely: SPT, RAST and RAST inhibition, lymphocyte (PBMC) proliferation and concomitant proinflammatory cytokine (IL-4) production, SDS-PAGE profiles, IgG and IgE immunoblotting allergograms, ELISA and ELISA-inhibition experiments. By employing these methods it has been proved that date pollen and fruit cultivars are differentially allergenic [33, 34].

When pollen from different cultivars were compared for their antigenic and allergenic potentials, results of ELISA, IgG and IgE immunoblot analyses, peripheral blood lymphocyte proliferation and concomitant IL-4 production clearly showed intercultural heterogeneity. This comparison revealed cultivars that were frankly allergenic as well as those that did not give any positive results in all the parameters examined. Additionally, there were individual differences in patient responses. Based on these observations, it has been concluded that the antigenicity and allergenicity of date palm pollen is more of a cultivar-specific phenomenon than a species-specific phenomenon. It was further postulated that this phenomenon is governed by the number, quantities or both of the major allergen epitopes possessed by that variety or cultivar [34]. Similar studies were extended to date fruit cultivars as well. By using the same parameters, these cultivars have been ranked into highly

allergenic, moderately allergenic and hypoallergenic [33]. The advantages of this ranking system is that it has made it possible to choose highly allergenic cultivars for the preparation of in-house pollen and fruit extracts for SPT, RAST, immunoblotting and for the immunotherapy. It has also become obvious that, even though IgE allergograms of both date pollen and fruits always showed avid binding (60–100%) to peptides at 54–58 kDa (in fruit) and to 57 and 65–67 kDa peptides (in pollen), these high molecular weight polypeptides, which are probably dimers and tetramers of the lower M_r bands may not be as functionally important major allergens as those of about 30 kDa and below: As is evident from the IgE immunoblots of the fruit cultivars (Fig. 4), all fruit cultivars investigated possess these higher molecular weight bands which recognize IgE in atopic sera. Thus, it can be concluded that in date palm allergy, these high M_r peptides do not confer overall allergenicity to extracts. Possession of the protein bands of 30–33 kDa and below appears to contribute more to allergenicity based on the properties used in the ranking system (Fig. 5).

Cross-reactivity of date palm allergens

Cross-reactivity is a property defined by individual antibodies to individual antigens or allergens. The most broadly distributed cross-reactive allergens are the pan-allergens, namely, profilin [62, 63], lipid transfer proteins [64, 65] and cross-reactive carbohydrate determinants [66–71].

Cross-reactivities are of clinical importance, therefore it is essential for allergist and patients to be aware of them especially for newly discovered allergens such as date palm allergens. The only reports on allergenic cross-reactivities between species belonging to the palm family Arecaceae (formerly Palmaceae) are those by Chowdhury et al., Chakraborty et al. and Kwaasi et al. [13, 38, 72]. Chowdhury et al. used pollen from *B. flabellifer*

and *P. sylvestris* to produce antisera in rabbits which was used in ELISA inhibition assays and RIE to study the antigenic relationship between palm pollen from the four palm species, namely, *Areca catechu*, *Borassus flabellifer*, *Cocos nucifera* and *Phoenix sylvestris*. Their results indicated the presence of common cross-reactive antigenic bands in all four palm pollen. Chakraborty et al. also studied a large number of patients who were sensitized to pollen from *P. sylvestris*, the date sugar palm, and Blanco et al. studied *P. canariensis*; both group of researchers were able to establish the allergenicity of these palms [37, 38].

Kwaasi et al. have shown that date palm pollen and fruit peptides are totally cross-reactive. In-house [73] fruit extracts from allergenic cultivars recognized all pollen allergens and *vice versa* [72]. An earlier study has established that date pollen cross-reacts with pollen of *Artemisia* at between 28 and 32 kDa. Cultivated rye (*Secale cereale*) and Timothy grass (*Phleum pratense*) both share a number of cross-reactive epitopes with date pollen at molecular weights of between 34 and 42 kDa. Bermuda grass (*Cynodon dactylon*) pollen is widely cross-reactivity and share as many as seven components with date pollen between 55 and 65 kDa [8]. Pollen from two genera of the Palmaceae family namely, *Washingtonia* spp. and coconut (*Cocos nucifera*), however, did not cross-react with date palm peptides [32]. Using immunoblotting and ELISA, it has been demonstrated that date palm polypeptides cross-react with birch pollen and Timothy grass pollen profilins, and up to 66% of date-sensitive patients bound IgE in date fruit profilin. Most date palm-allergic patients are polysensitized to a number of pollen and food allergens. Cross-reactivities between date palm peptides and some foods to which some date-sensitive patients react and have been implicated in the oral allergy syndrome (OAS) have been studied [72]. It is now clear that date peptides cross-react with components in apple, apricot, asparagus, avocado, banana, beans, bell pepper, celery, fig, kiwi, mango, melon, olives, spinach, strawberry and tomato. The probability that date palm allergens possess cross-reactive carbohydrate determinants (CCDs) has also been investigated. Experiments in which date fruit peptides were treated with endoglycosidases before immunoblotting with atopic human sera have clearly indicated that IgE-binding was inhibited by

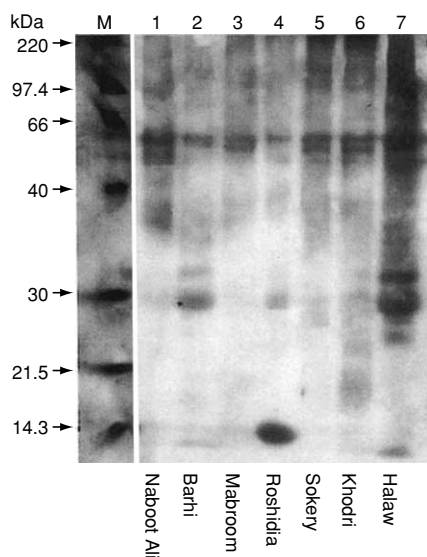


Fig. 4. IgE immunoblots of seven date fruit cultivars. Fruit components were reacted with pooled date fruit-positive human sera and immunostained with goat anti-human IgE. M, molecular weight marker; kDa, kilodaltons; 1–7 demonstrate banding patterns of different cultivars. Note the presence of the major allergen Pho d f3 of 54–58 kDa in all cultivars.

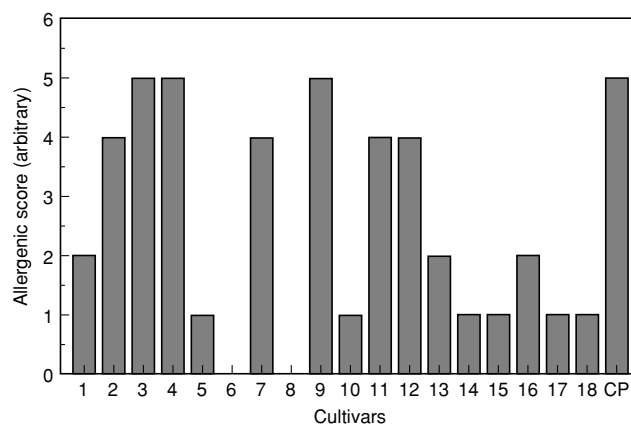


Fig. 5. Histogram showing the ranking of 18 different fruit cultivars according to their allergenic properties. A score of 1 was assigned to a cultivar only if it evoked an SPT reaction in 4–6 of a total of six patients, had an IgE ELISA score of ≥ 0.5 , bound IgE at 14.3 kDa, 27–33 kDa or possessed more than eight IgE immunoblot bands.

endoglycosidase digestion in all apart from a low molecular weight peptides of < 12 kDa. Furthermore, immunoblot inhibition results hinted at the probability that low molecular weight proteins like lipid transfer proteins (LTPs) may be involved in the allergenicity of date peptides. The reason for this surmise is that lipid transfer proteins are resilient to enzymatic digest as was evident when date fruit peptides were digested with different endoglycosidases. The IgE binding of the very low molecular weight bands at *c.* 12 kDa and below in date fruits could not be inhibited by endoglycosidase treatment of the extracts whilst all the bands above this *M_r* did not bind IgE. Most of the cross-reactive fruit and vegetables (apple, peach, kiwi, melon, strawberry and celery) are known to contain lipid transfer proteins [64, 65]. Further studied are needed for a clear understanding of how these cross-reactive structures in these foods and dates affect the allergic status of date-sensitive individuals.

Amino acid sequence homology of major date palm allergens

The major date allergens of 6.5–14.3 and 28–33 kDa corresponding to Pho d f1 and Pho d f2 (see Fig. 6b) from date fruits and the 12, 14.4 and 27–30 kDa corresponding to Pho d 1, Pho d 2 and Pho d 5 (see Fig. 6a, lanes 3, 2 and 1, respectively) were sequentially purified by Sephadex G-75, Sephacryl S-200 and Bio-Rad (Hemel Hempstead, Herts, UK) TSK-HPLC size exclusion chromatography [74]. Putative date pollen and fruit profilins were also isolated by affinity chromatography on a cyanogen bromide (CNBr)-activated Sepharose 4B coupled to Poly L-Proline column and purified by standard methods [72–75]. Distinct protein bands from the above-mentioned procedures were obtained by SDS-PAGE and visualized on Coomassie brilliant blue (CBB)-stained gels (Figs 6a and b). Individual bands (as marked by boxes in Fig. 6) were excised and electroeluted, or were 'in-gel' digested with trypsin and analysed by matrix-assisted laser desorption/ionization (MALDI) mass spectrometry [76, 77]. The amino acid sequences of the digests were determined using a QSTAR (Quadrupole-TOF mass spectrometer). The resultant amino acid sequences were queried against Swiss, NRDB, EST and

other databases for exact identification or homology to known proteins. Results of amino acid sequencing indicated that date-allergenic peptides are novel but share sequence homology with families of known allergens, namely profilins, wound-induced, pathogenicity-related (PR), acidic class III chitinase and endochitinase proteins [78–80].

The 14-kDa peptide bands from the date fruit (Fig. 6b, lane 3c; Pho d f1) and pollen Pho d(2) are isoallergens and share sequence homology to a wound-induced protein of 22 498 kDa and a PR protein of 15 693 kDa. The *c.* 30 kDa major allergens in date pollen (Pho d 5) and date fruit (Pho d f2) are also identical and share homologous sequences with two proteins namely an endochitinase protein of 31 229.64 kDa and acidic class III chitinase from oats (*Oryza sativa*). The *c.* 14 kDa putative date palm profilin, which cross-reacts with Timothy grass and birch pollen profilins [72], share sequence homologies with the wheat profilin pro3_wheat profilin-3 and to win2_soltu2_wound-induced protein w. The very low molecular weight peptides of ≤ 12 kDa in date pollen (Fig 6a, lane 3, and Fig. 6b, lane 3a) are novel peptides that do not share sequence homologies to any listed proteins or peptides [74]. The novel peptide from date fruits was resistant to endoglycosidase digest and did not bind IgE in patient sera.

The role of sandstorms in exacerbation of allergy, asthma and other respiratory tract infections

Airborne aeroallergens, particulate matter and organic vapours in the outdoor environments, farms, industries and in homes can cause rhinitis, asthma, allergies and a host of other upper respiratory tract infections [35]. Any organic dust or volatile chemical that is reactive with proteins may cause allergic rhinitis, asthma or hypersensitivity pneumonitis [81, 82] and it has been reported that viable micro-organisms in dust are responsible for most work-related upper respiratory tract infections [83].

Sandstorms are common in Saudi Arabia and neighbouring countries. Just as episodes of thunderstorms are capable of causing epidemics of asthma in different parts of the world, and *Parietaria* pollen is the main allergic sensitizer in the Mediterranean countries, so sandstorms are capable of causing exacerbations of allergy, asthma, sinusitis and other respiratory diseases in Saudi Arabia and date palm pollen allergens and components of sandstorm dust the main allergic sensitizers. These facts are further complicated, to the detriment of asthma and allergy sufferers, by the following points: apart from the indigenous desert plants there are a lot of imported plant species in Saudi Arabia, and pollen and non-pollen parts of these and other locally available allergenic plants (mainly from the families Gramineaceae, Amaranthaceae, Chenopodiaceae and Leguminosae) dry up very quickly in the hot environment, break into smaller airborne particles (< PM10) and are easily blown around. Recent work has shown that these submicronic allergen particles can penetrate deep into the lungs and are responsible for most inhalation allergy [84]. There are a number of milling plants throughout Saudi Arabia and parts of the Middle East where different cereal grains and pulses are ground to cater for the nutritional needs of the diverse expatriate communities that live in parts of the Middle East. Mites, weevils and arthropod parts in infested grain and in the natural fauna also dry up and

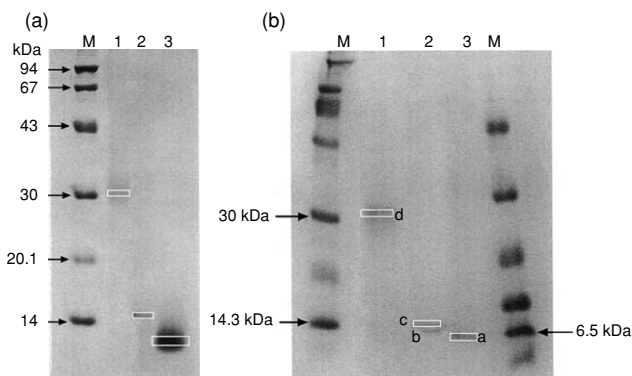


Fig. 6. SDS-PAGE of some purified major date pollen (a) and fruit (b) allergens. These purified pollen and fruit extracts as shown by the rectangular boxes were 'in-gel' digested. (a) The major pollen allergens of 12, 14.4 and 27–30 kDa corresponding to Pho d 1, Pho d 2 and Pho d 5 (lanes 3, 2 and 1, respectively) and the major date fruit allergens of 6.5–14.3 and 28–33 kDa (b) corresponding to Pho d f1 (lanes 2–4 annotated a, b and c) and Pho d f2 (lane 1) are shown.

become airborne. There are a number of feral cats in Saudi Arabia and their fur plays a major role both as indoor and outdoor major allergens, and so are fungal and bacterial propagules entrapped in the fine dust [35, 85]. Microbiological and immunochemical methods have been employed to determine the aeroallergenic and microbial content of sandstorm dust. It has been estimated that *Pseudomonas*, *Staphylococcus* and *Bacillus* species were the most frequently isolated bacteria and *Alternaria*, *Aspergillus* and *Cladosporium* spp. the most abundant fungal species [35]. Most of these organisms cause respiratory symptoms such as chest tightness, wheeze and nasal or eye irritation. These fungi have also been associated with allergic and non-allergic diseases: *Alternaria alternata* in particular can cause severe asthma, and is capable of inducing respiratory arrest in children and in young adult asthmatics [86]. Additionally, some species of Ascomycotina fungi that are found in sandstorm dust can cause allergic and immunotoxic respiratory disorders [35]. Members of the dematiaceous family of fungi, to which *Alternaria*, some *Mycelia sterilia* and *Aspergillus* spp. belong, are commonly implicated in allergic fungal sinusitis [87]. Thus, the potential hazards posed by sandstorms and its component could be phenomenal!

Had the vivid and apt descriptions of Plinius the Younger's [88] referring to 'clouds of airborne matter' and their ability to cause 'inflammation of the airways' been heeded to some 2000 years ago, our understanding of the impact of pollution on allergy and asthma would be better than it is today.

General discussion and conclusions

Some of the factors that have been implicated in the rise in prevalence of allergic manifestations include increase in environmental pollutants, geographical location, socioeconomic status, including adoption of a Western European lifestyle, high allergen load, sudden changes in meteorological conditions and automobile exhaust fumes, to mention a few [20, 21, 89, 90].

Food allergy or intolerance is now common in most parts of the Western world and episodes of fatal anaphylaxis have been reported. The affluence of the Saudi and other Middle Eastern societies has led to the introduction of Western foods, fast foods that are ideal for the introduction of novel forms of food allergies and intolerances. The excessive growth of imported plants adds to the pollen load in the environment and the new foods and their additives prime susceptible individuals to get sensitized to an array of cross-reactive plant pollen and food allergens. Introduction of new plants also means that there is an increase in the number of plant pathogens, which help increase the overall microbial load in the environment.

It is known that carpeted floors carry a lot of indoor (mites, cockroaches, cat, rodent and insects) allergens, which serve as sensitizers of allergic manifestations. This concern has made it necessary for the Norwegian government to remove all carpets from the floors of some infant schools and these have been replaced by linoleums [91]. In Saudi Arabia, a great number (if not all) of homes are carpeted and air-conditioned, a combination that is suitable for the habitation of most fungi, dust mites, cockroach and other allergens. However, if it is true that adoption of westernized style of living leads to an increase in asthma, atopic eczema and other allergic diseases, then most of the increase in allergies in the Middle East (including Saudi

Arabia) can be attributed in part, to this factor as well as urbanization as 75% of the Saudi population lives in urban areas. If all the factors thought to be responsible for the increase in the worldwide incidence of allergic manifestations are to be considered in relation to Saudi Arabia and the neighbouring countries, then the rise in incidence can be easily explained. Date palm is indigenous to these parts of the world and trees can be found everywhere and in almost every compound or home. The palm produces a lot of pollen and there are sporadic sandstorms laden with a lot of aeroallergens and microbes, which blow dust and pollen to every part of the Middle East and beyond [35]. There are hardly any rains for about 10 months of the year and this is also made worse by the numerous automobile vehicles that are used per household in the Middle East. The preceding lines have indicated clearly that the environmental and socio-economic status of the majority of people in Saudi Arabia and the Middle East as a whole has changed to Western affluence and there has been the introduction of new plants and foods and therefore allergens.

Quo vadis in date palm allergy research

It is apparent therefore that the only way ahead to reduce the prevalence of allergy and asthma in general is to (i) study the true prevalence of allergic manifestations in Saudi Arabia; (ii) identify and characterize all known allergens; (iii) find out the sensitizing allergen(s) backed by double-blind placebo studies; (iv) prepare immunodiagnostic and therapeutic extracts from these for allergy diagnosis and specific immunotherapy; (v) when these studies have been completed and the sensitizing allergens identified. Regulations can be put in place aiming at addressing changes in the environment to directly or indirectly reduce the allergen load; (vi) further strict phytopathological regulations should be implemented to control the importation of new allergenic plants; and (vii) quarantine methods should be efficient so that material infested with insects or other arthropods, bacteria and fungi are destroyed.

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