

Allergen Data Collection:**Almond** (*Prunus dulcis*)

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Authors in alphabetical order [[contact information](#)]

Matthias BESLER (Hamburg, Germany)

Julia RODRÍGUEZ (Madrid, Spain)

Steve L. TAYLOR (Lincoln, NE, USA)

Abstract

IgE-mediated adverse reactions to almonds have been reported by several investigations. Prevalence data vary considerably with different patient cohorts and between studies from different countries. Allergic symptoms due to almond ingestion range from milder oral symptoms to life-threatening systemic reactions.

Although they belong to the family of Rosaceae fruits (e.g. apple, peach, and apricot), almonds are most often classified as tree nuts. As such almonds are included in the Codex Alimentarius list of allergens which should always be declared on the label of pre-packaged foods. Almonds are used in various forms (whole, chopped, sliced, or paste) predominantly in bakery products such as cookies, cakes, and pies as well as in confectionary products. Almonds are a source of gourmet edible oils that potentially contain residual allergens.

There is only limited information on almond allergens. Two major allergens with approximately 66-70 kDa and 45-50 kDa have been identified. The latter proved to be stable during food processing such as blanching and roasting of almonds. Moreover, the plant-pan allergen profilin is also present in almonds, and recent studies indicate the presence of another plant-pan allergen in almonds: a lipid-transfer protein. Almond allergens demonstrate in-vitro cross-reactivity of IgE binding to other tree nuts and fruits from the Rosaceae family.

Detailed information on prevalence, symptoms, and diagnostic features of almond allergy are reviewed in tabular form. The terms "nuts" or "tree nuts" refer to shell (nut) fruits of various botanical families. In the present Allergen Data Collection nuts or tree nuts include almonds, Brazil nuts, cashew nuts, hazelnuts, pecannuts, pistachios, and walnuts. Other tree nuts that are not commonly allergenic include nutmegs, shea nuts, and Kola nuts. Unless not otherwise stated peanuts, chestnuts, and coconuts are not included.

(Internet Symposium on Food Allergens 2001, 3(2):71-85)

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Disclaimer

The reference lists of the Allergen Data Collections are based mainly on searches of Medline and FSTA (Food Science & Technology Abstracts) databases up to the related dates of publication. The scientific rigor of the studies listed is variable and not subject of critique or evaluation by the authors or the editor of the Allergen Data Collections. The reader should be aware of considerable problems in comparing data from different studies (eg. patient cohorts, diagnostic performances, possible flaws in allergen preparations and methodologies for allergen characterization) and is encouraged to review the original publications.

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1 Prevalence of Almond Allergy

Prevalence data are based on different diagnostic procedures. While the prevalence of sensitization (sensitivity) can be estimated by SPT, RAST, and immunoblot, a clinical relevant sensitization (allergy) is evaluated by convincing history (anamnesis) or food challenge tests (ideally by DBPCFC).

1.1 General Population

Prevalence estimates within the author's selected populations are listed. Those that are assigned randomly selected ("unselected") with numbers more than 500 may be regarded as representative of the "general populations". Inclusion criteria may involve circumstances not related to atopic predisposition according to current knowledge.

Country / Subjects	Allergy / Sensitivity	References
<i>Australia, Victoria</i> a) 332 unselected new-born infants b) 4078 children with suspected peanut or tree nut allergy (age < 14 years) (study 1990-96) c) 620 children at risk of atopy (followed from birth for 2 years)	almond 0.02% (calculated) (frequency of almond allergy in b), corrected for prevalence ratio to peanut allergy in b) and c), extrapolated by risk of atopy in a)	Hill et al. 1997

1.2 Subjects with Atopic or Other Diseases

Country / Subjects	Allergy / Sensitivity	References
<i>Australia, Victoria</i> 4078 children with suspected peanut or tree nut allergy (age < 14 years) (study 1990-96)	almond 4.2% (SPT >3+, n=336)	Sporik & Hill 1996
<i>Canada, Toronto, Ontario</i> 45 patients with classic food allergic symptoms and/or subjective food related complaints	almond, walnut 2.2% (SPT)	Parker et al. 1990
<i>Costa Rica</i> 171 children (68 asthmatics, 103 non-asthmatics)	almond 50% (specific IgE in MAST)	Soto-Quiros et al. 1998
<i>Croatia</i> 71 confectionary workers with occupational respiratory allergies (bronchitis, dyspnea, asthma)	almond 4.2% (SPT)	Zuskin et al. 1994
<i>Finland</i> 80 food handlers with hand dermatitis	almond 5% (n=60, scratch chamber test)	Niinimaki 1987
<i>France, Nancy</i> 196 cases of involving plant food allergens (from 509 cases of food allergy)	Rosaceae fruits including almonds 17% (clinical evaluation)	Moneret-Vautrin et al. 1997
<i>France, Nancy</i> 142 patients with peanut allergy	almond 50% (clinical evaluation)	Moneret-Vautrin et al. 1998
<i>France, Nancy and Toulouse</i> 544 food allergic children	almond 0.6% (food challenge)	Rance et al. 1999
<i>France, Pierre Benite</i> 60 cases of anaphylaxis (study period 1984-92)	almond 1.7%	Andre et al. 1994
<i>Germany, Ulm</i> 80 patients with pollen associated food allergy	almond 65% (clinical history, SPT)	Boehncke et al. 1998
<i>Italy, Ferrara</i> 169 grass pollen allergic patients (age of 9-54 years, mean 27.9)	almond 4% (clinical history)	Boccafogli et al. 1994

Italy, Genoa 132 pollen and food sensitive patients	almond 6.6% (incidents of hypersensitivity)	Troise et al. 1992
Italy, Milan 262 fruit and/or vegetable allergic patients	almond 22% (clinical history)	Ortolani et al. 1988
Italy, Milan 100 fruit and/or vegetable allergic patients	almond 6% (clinical history)	Ortolani et al. 1989
Italy, Milan 30 apricot allergic patients	almond 13% (clinical history)	Pastorello et al. 2000
Israel, Tel-Aviv 112 patients with food allergy (onset after 10 years of age)	a) almond 55% (SPT, n=108) b) almond 39% (food challenge, n=71)	Kivity et al. 1994
Spain, Barcelona 102 patients allergic to dried fruits	almond 89%, 81%, and 60% (SPT, HR, and RAST)	Amat Par et al. 1990
Spain, Gran Canaria 102 adults with symptoms after ingestion of specific foods	almond 7.5% (SPT, RAST)	Castillo et al. 1996
Spain, Madrid??? 40 patients with fruit or vegetable allergy	almond 43% (SPT, RAST, PK tests)	Hernandez et al. 1985
Spain, Madrid a) 48 children with pollinosis b) 42 children with fruit or vegetable allergy	a) almond 0% (SPT), 2.1% (RAST) b) almond 17% (SPT), 12% (RAST)	Caballero et al 1994
Spain, Madrid 355 food allergic children	almond 3.7% (clinical history, open food challenge, SPT, RAST)	Crespo et al. 1995a
Spain, Madrid 29 plant-derived food allergic patients	almond 6.9% (SPT) almond 0% (RAST)	Diez-Gomez et al. 1999
Spain, Plasencia (Caceres) 262 patients with pollinosis	almond 2.2% (self-reported) almond 1.5% (SPT)	Garcia-Ortiz et al. 1995
Spain, Salamanca a) 84 mugwort sensitive patients without other pollen sensitizations b) 57 fruit allergic patients (age of 6-56 years, mean 21.5)	a) almond 1.2% (RAST) b) almond 14%(clinical history)	a) Garcia-Ortiz et al. 1996 b) Garcia Ortiz et al. 1998
Spain, Salamanca 95 pollen allergic patients (age 10-58 years, mean 27)	almond 16% (SPT) almond 1% (food challenge)	Cuesta-Herranz et al. 2000
Sweden 60 severe allergic reactions caused by food	soybean, nuts, and almonds >70%	Foucard et al. 1997
Sweden, Halmstad / Malmö a) 380 birch pollen allergic patients b) 103 patients without birch pollen allergy	a) almond 27% b) almond 3% (questionnaire)	Eriksson et al. 1982
Switzerland, Zurich a) 402 food allergic adults (study period 1978-87) b) 383 food allergic patients (study period 1990-94)	a) almond 1.7% b) almond 11% (anamnesis, clinical relevance, diagnostic tests)	a) Wüthrich 1993 b) Etesamifar & Wüthrich 1998
United Kingdom, London 119 patients with possible food allergies	almond 3.4% (RAST, elimination-challenge test)	Wraith et al. 1979
USA, Boston, MA 63 asthmatic adults with positive food-induced skin scratch tests	almond 3.2% (skin scratch test)	Rackemann 1931
USA, Galveston, TX / Philadelphia, PA 26 patients with atopic dermatitis associated with ingestion of various foods	almond 3.8% (clinical history, elimination diet)	Livingood & Pillsbury 1949

UK, Manchester 90 patients experienced anaphylactic reactions to foods (from 1994-1996)	almond 3.3% (suspected cause of patients' worst reaction)	Pumphrey & Stanworth 1996
USA, Little Rock, AR / New York City, NY 54 tree nut allergic patients	almond 24% (acute allergic reactions)	Sicherer et al. 1998b
USA, Los Angeles, CA 127 pediatric patients who reported one or more food allergies	almond 3.9% (RAST)	Hoffman & Haddad 1974
USA, Memphis, TN 89 patients with food- induced anaphylaxis (age of 12-75 years, study period 1978-92)	almond or peach 5.6% (clinical history)	Kemp et al. 1995
USA, Mineola, NY 30 patients with gastrointestinal symptoms associated with food allergies	almond and Brazil nut 1 case almond, walnut, and Brazil nut 1 case (intracutaneous skin test, oral challenge with mixture of foods)	Fries & Zizmor 1940
USA, Rochester, MN a) 18 patients with food- related anaphylaxis b) 81 patients	a) almond 5.6% (history, SPT, and RAST) b) almond 19% (SPT)	Yocum & Khan 1994
USA, Torrance, CA 8 patients with oral allergy syndrome to avocado and positive history	almond 12.5% (self-reportedly cause of OAS; no clinical confirmation)	Telez-Diaz et al. 1995
USA, Torrance, CA 40 of 62 patients from an adult outpatient HIV clinic who reported symptoms compatible with food allergy	almonds and peanuts 1 case (self-reportedly cause of diarrhea and headache; no clinical confirmation)	Tubiolo et al. 1997

1.3 Prevalence of Associated Allergies

Country / Subjects	Sensitization / Allergy	References
France, Italy, Netherlands 37 patients with Rosaceae allergy and positive SPT to lipid-transfer protein enriched extracts (plum / peach peel)	peach 81% apple 43% apricot 30% cherry 24% plum 22% almond 19% pear 16% (clinical history) walnut 51% hazelnut 41% peanut 24% (self reported)	Asero et al. 2000
Germany, Ulm 52 almond allergic patients selected out of 80 patients with pollen associated food allergy	birch pollen 98% (clinical history, SPT)	Boehncke et al. 1998
Spain, Barcelona 78 almond allergic patients	tree pollen tree (elm, olive, birch, plane, ash) 59% weed pollen (parietaria, mugwort) 38% grass pollen 13% (2 positive results from SPT, HR, and RAST)	Amat Par et al. 1990
Spain, Madrid 55 children sensitized to almonds	pollen 80% (SPT)	Crespo et al. 1995b

	Clinical history and SPT and/or RAST	a)	b)	
<p>Spain, Madrid and Toledo Patients with allergy to <i>Rosaceae</i> fruits a) 11 without pollinosis (mean age 26 years) b) 22 with associated pollinosis (mean age 22 years)</p>	peach	91%	100%	Fernandez-Rivas et al. 1997
	apple	91%	68%	
	pear	27%	55%	
	cherry	36%	27%	
	apricot	18%	23%	
	plum	36%	23%	
	strawberry	-	14%	
	almond	9%	14%	
	melon, watermelon, cucumber	0%	50%	
	nuts and seeds	50%	59%	
	various plant foods	18%	41%	
<p>Spain, Madrid 28 patients with positive SPT and/or specific IgE to one or more fruits of the <i>Rosaceae</i> family</p>	peach 79% apple 21% apricot 18% plum 14% almond 3.6% pear 3.6% strawberry 3.6% (DBPCFC or convincing episode of anaphylaxis)			Rodríguez et al. 2000
<p>Spain, Salamanca 8 almond allergic patients</p>	latex 75% (SPT and/or RAST) latex 25% (clinical history)			Garcia Ortiz et al. 1998
<p>UK, Cambridge 62 patients with peanut and/or nut allergy (age of 11 months to 53 years)</p>	peanut 65% brazil nut 29% almond 23% hazelnut 21% walnut 13% cashew nut 4.8% (clinical history, SPT)			Ewan 1996

2 Symptoms of Almond Allergy

Symptoms & Case Reports	References
<p><u>Systemic reactions</u> anaphylaxis (5), life-threatening reactions (7), loss of consciousness (4)</p> <p><u>Symptoms of skin and mucous membranes</u> angioedema (3, 9), urticaria (1, 3, 8)</p> <p><u>Gastrointestinal symptoms</u> oral angioedema (4, 7), laryngeal edema (2, 4, 9), oral hives (7), oral itching (7), oral allergy syndrome (2, 3, 6, 8, 9), vomiting (4)</p> <p><u>Respiratory symptoms</u> asthma (4), dyspnea (9)</p> <p><u>Other symptoms</u> general malaise (9)</p>	<p>(1) Schloss 1912 (2) Ortolani et al. 1988 (3) Boccafogli et al. 1994 (4) Ewan 1996 (5) De las Marinas et al. 1998 (6) Garcia Ortiz et al. 1998 (7) Roux et al. 1999 (8) Asero et al. 2000 (9) Pasini et al. 2000</p>
<p>Percentage of reactions Oral allergy syndrome in 75% (plus systemic reactions in 16%) and extra-oral symptoms in 25% in 57 almond allergic patients (1)</p>	<p>(1) Ortolani et al. 1988</p>

3 Diagnostic Features of Almond Allergy

Parameters / Subjects	Outcome	References
<p>Skin test A boy with urticaria provoked by ingestion of almond, egg, and oatmeal</p>	<p>Skin testing with demonstration of urticarial lesion</p>	<p>Schloss 1912</p>
<p>Skin test, Systemic Reaction An almond sensitive individual</p>	<p>A case of systemic reaction following skin test</p>	<p>Kahn 1942</p>
<p>IgE tree nut allergic patients: a) 11 reacting b) 25 not reacting to almonds</p>	<p>Almond specific serum IgE (RAST): mean median a) 17.1 kU/L 3.8 kU/L b) 14.5 kU/L 1.8 kU/L (no significant differences, P value 0.81)</p>	<p>Sicherer et al. 1998b</p>
<p>IgE and Clinical Relevance 25 patients with atopic dermatitis</p>	<p>44% had positive RAST to almonds. However, none of the patients apparently mentioned almonds as a cause of allergic sensitivity</p>	<p>Hoffman et al. 1975</p>
<p>IgE and Clinical Relevance 67 asthmatic children</p>	<p>Agreement of history of almond allergy and almond specific serum IgE (MAST): positive history and positive MAST in 3 children, positive MAST and no positive history in 4 children and, positive history and a negative MAST in 3 children</p>	<p>Adler et al. 1991</p>
<p>IgE and Clinical Relevance 43 patients with clinical history and positive SPT to almond</p>	<p>Almond specific RAST: positive 42% negative 58%</p>	<p>Boehncke et al. 1998</p>
<p>IgE and Clinical Relevance A 3 year old boy with peanut allergy</p>	<p>Strong positive RAST to almond, although no almond allergy was described in history; also high RAST to peanut, hazelnut, Brazil nut, pecan, pistachio, walnut, and pea.</p>	<p>Sicherer et al. 1998a</p>

<p>SPT, IgE and Clinical Relevance a) 24 and b) 43 patients with clinical history of almond allergy</p>	<p>a) RAST (specific IgE): positive results in 25% b) SPT with fresh food: positive results in 30%</p>	<p>Ortolani et al. 1988</p>								
<p>SPT, IgE and Clinical Relevance 6 patients with clinical history of almond allergy</p>	<p>RAST (specific IgE > 0.7 kU/L): positive results in 17% SPT with fresh food: positive results in 17%</p>	<p>Ortolani et al. 1989</p>								
<p>SPT, RAST, Histamine Release and Clinical Relevance 102 patients allergic to dried fruits</p>	<p>Correlation of tests to clinical history of almond allergy: 89% for SPT 87% for HR 68% for RAST</p>	<p>Amat Par et al. 1990</p>								
<p>SPT, IgE, and DBPCFC 28 patients with suspected allergy to fruits of the Rosaceae family</p>	<table border="1"> <thead> <tr> <th>Almond</th> <th>Positivity</th> </tr> </thead> <tbody> <tr> <td>SPT</td> <td>54%</td> </tr> <tr> <td>RAST</td> <td>21%</td> </tr> <tr> <td>DBPCFC*</td> <td>3.6%</td> </tr> </tbody> </table> <p>* or convincing episode of anaphylaxis</p>	Almond	Positivity	SPT	54%	RAST	21%	DBPCFC*	3.6%	<p>Rodríguez et al. 2000</p>
Almond	Positivity									
SPT	54%									
RAST	21%									
DBPCFC*	3.6%									
<p>Immunoblot and Clinical Relevance a) 2 symptomatic patients with almond allergy (SPT positive, RAST negative) b) 3 asymptomatic subjects with positive RAST</p>	<p>IgE binding almond proteins: a) 37-kDa protein b) 50-kDa and 62-kDa glycoproteins (Con A reactive bands) (SDS-PAGE Immunoblot)</p>	<p>Pasini et al. 2000</p>								
<p>Open Challenge 17 children with perceived peanut or tree nut allergy (almond suspected cause in 2 cases)</p>	<p>Open challenge procedure, where negative tests (SPT, RAST) indicate tolerance of nuts: 15 showed no reactions, all of them continued to ingest foods containing nuts without incidents.</p>	<p>Baker et al. 1999</p>								

4 Therapy of Almond Allergy

Treatment*	Outcome	References																				
<p>Tree Pollen Immunotherapy 72 children with birch pollinosis (age of 6-16 years), prevalence of adverse reactions to almond before immunotherapy 50% I. subcutaneous immunotherapy for 3 years with a) birch pollen preparation or b) a mixture of birch, alder, and hazel pollen II. oral immunotherapy for 10 months with c) birch pollen preparation or d) placebo capsules</p>	<p>Assessment of food allergy after treatment (self-reported):</p> <table border="1"> <thead> <tr> <th></th> <th>improved</th> <th>unchanged</th> <th>worse</th> </tr> </thead> <tbody> <tr> <td>a) (n=19)</td> <td>37%</td> <td>42%</td> <td>21%</td> </tr> <tr> <td>b) (n=20)</td> <td>55%</td> <td>30%</td> <td>15%</td> </tr> <tr> <td>c) (n=14)</td> <td>21%</td> <td>64%</td> <td>14%</td> </tr> <tr> <td>d) (n=14)</td> <td>14%</td> <td>86%</td> <td>0%</td> </tr> </tbody> </table> <p>no significant more decrease in birch pollen immunotherapies as compared to placebo oral immunotherapy</p>		improved	unchanged	worse	a) (n=19)	37%	42%	21%	b) (n=20)	55%	30%	15%	c) (n=14)	21%	64%	14%	d) (n=14)	14%	86%	0%	<p>Möller 1989</p>
	improved	unchanged	worse																			
a) (n=19)	37%	42%	21%																			
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d) (n=14)	14%	86%	0%																			

* Studies may be experimental, unproved, or controversial. Please notice the [disclaimer](#) !

5 Composition of Almonds

5.1 Distribution of Nutrients

For other almond products see: [USDA Nutrient Database](#)

Nutrients: Content per 100 g		
Energy 2527 kJ (598 kcal) Water 5.7 g Protein 18.7 g Lipids 54.1 g Carbohydrate 9.0 g Fiber 9.8 g Minerals 2.7 g Minerals Sodium 5-40 mg Potassium 835 mg Magnesium 170 mg Calcium 250 mg Manganese 2 mg Iron 4 mg Copper 850 µg Zinc 2 mg Phosphorus 455 mg Chloride 40 mg Fluoride 90 µg Iodine 2 µg Selenium 2 µg	Vitamins Carotene 120 µg Vitamin E 25 mg Vitamin B1 220 µg Vitamin B2 620 µg Nicotinamide 4180 µg Pantothenic acid 580 µg Vitamin B6 60 µg Biotin 0-20 µg Folic acid 45 µg Vitamin C 0.8-6.5 mg Amino Acids Arg 2750 mg His 520 mg Ile 880 mg Leu 1460 mg Lys 580 mg Met 270 mg Phe 1160 mg Thr 610 mg Trp 170 mg	Tyr 620 mg Val 1140 mg Lipids Palmitic acid 3260 mg Stearic acid 900 mg Oleic acid 36.5 g Linolic acid 9860 mg Linoleic acid 260 mg Other Salicylic acid 3 mg Purines 30 mg

Reference: Deutsche Forschungsanstalt für Lebensmittelchemie, Garching bei München (ed), **Der kleine "Souci-Fachmann-Kraut" Lebensmitteltabelle für die Praxis**, WVG, Stuttgart 1991

5.2 Protein Fraction

Proteins / Glycoproteins	Amount of total protein
<i>Soluble fractions</i>	
albumins (water-soluble)	>95% (1)
almond major protein [460 kDa] amandin (in 14S) (= classical globulin fraction)	up to 65% (3) 65-70% (2)

References: (1) [Sathe 1993](#), (2) [Wolf & Sathe 1998](#), (3) [Acosta et al. 1999](#)

6 Allergens of Almond

Proteins / Glycoproteins	Allergen Nomenclature	References
37-kDa Allergen		Pasini et al. 2000
Almond Profilin		van Ree et al. 1992, 2000
Allergens: 45-50, and 70 kDa Minor Allergens: 15 kDa		Bargman et al. 1992
Allergens: 50 kDa and 66 kDa Minor Allergens: 10, 28, 37, and 39-44 kDa		Roux et al. 1999

6.1 Sensitization to Almond Allergens

Country / Subjects	Sensitivity to	References	
<i>Italy, Padova</i> 2 almond allergic patients	37 kDa allergen (SDS-PAGE immunoblot)	Pasini et al. 2000	
<i>Netherlands, Amsterdam</i> 2 patients with pollen profilin specific serum IgE	Specific IgE against almond profilin 6.9 and 3.0 IU/ml (RAST, L-proline Sepharose bound profilin)	van Ree et al. 2000	
<i>USA, Davis, CA</i> a) 14 patients with history of life-threatening reaction to almonds b) 11 patients with history of non-life-threatening reactions to almonds			
		a) b)	
	albumin/globulin fraction	86%	
	almond major protein	79%	
	66 kDa allergen	64%	55%
	55 kDa allergen		18%
	50 kDa allergen	64%	55%
	39-44 kDa allergen	29%	
	37 kDa allergen	7%	
28 kDa allergen	7%	27%	
17 kDa allergen		9%	
10 kDa allergen	21%	18%	
(SDS-PAGE immunoblot)			
<i>USA, Lincoln, NE</i> 8 almond sensitive patients	70 kDa allergen 45-50 kDa allergen 15 kDa allergen (SDS-PAGE / immunoblot)	in 50% in 50% in 25% Bargman et al. 1992	

7 Isolation & Preparation

Extract / Purified Allergens	Methods	References
Protein extract	Ground whole almonds defatted with acetone and ethyl ether; dried almond powder extracted with NaCl pH 7.0, centrifuged, dialyzed, centrifuged again, and membrane filtered	Bargman et al. 1992
Protein extract	Almonds finely chopped, extracted with Tris-HCl-buffer pH 8.0 (containing glycerol, polyethylene glycol 8000, citric acid, L-cysteine, L-ascorbic acid, EDTA, and polyvinylpyrrolidone); followed by homogenization on ice, centrifugation, membrane filtration and membrane concentration	Teuber & Peterson 1999
Salt-soluble proteins	Raw whole almonds grounded, defatted with petroleum ether, extracted with 0.5-M NaCl for 2h; after centrifugation protein was precipitated with acetone at 4°C for 30 min; after centrifugation protein extract was resolubilized in SDS-PAGE sample buffer	Pasini et al. 2000
Almond major protein [460 kDa]	Defatted almond flour extracted with Tris-HCl buffer (pH 8.1), centrifuged and isolation of the almond major protein from supernatant by anion exchange (DEAE column) and gel filtration (Sephacryl column) chromatography, collected fractions pooled and concentrated by membrane filtration, further purification by gel filtration	Acosta et al. 1999

Food extracts	Food samples ground and extracted with PBS-buffer at 60°C for 2h, centrifuged and supernatant stored at -20°C	Hlywka et al. 2000
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8 Cross-Reactivities

Cross-Reacting Allergens	Subjects / Methods	References
<i>Almond (Peanut)</i> peanut	Inhibition of IgE-binding: by peanut to almond proteins (1 patient, RAST inhibition)	Gillespie et al. 1976
<i>Almond (Peanut, Nuts)</i> significant associations: peanut, hazelnut, walnut*	262 fruit and/or vegetable allergic patients (clinical history, SPT, RAST)	Ortolani et al. 1988
<i>Almond (Nuts, Seeds)</i> hazelnut, brazil nut, sesame seeds *	111 peanut and/or tree nut allergic patients: strong correlation ($r > 0.7$) between almond and hazelnut, brazil nut, and sesame (RAST)	Sicherer et al. 1998b
<i>Almond (Nuts)</i> hazelnut	6 hazelnut allergic adults: Inhibition of IgE binding to hazelnut proteins by almond proteins (appr. 8%) (RAST inhibition)	Koppelman et al. 1999
<i>Almond (Nuts)</i> coconut, walnut	Strong inhibition of IgE binding to coconut allergens (35, 36.5 and 55 kDa) and to walnut allergen (36 kDa) by almond extract (SDS-PAGE immunoblot, 2 tree nut allergic patients)	Teuber & Peterson 1999
<i>Almond (Apple)</i> apple (indicating allergenic lipid-transfer proteins)	Approximately 98% inhibition of IgE binding to almond proteins by apple peel extract in 1 patient serum specific for lipid-transfer proteins without reactivity to Bet v 1, profilin, and carbohydrate epitopes (RAST inhibition)	Asero et al. 2000
<i>Almond (Rye)</i> rye flour *	Correlation between specific IgE to rye flour and nuts (peanut, almond, brazil nut, coconut, hazelnut) (3310 atopic patients, RAST, $r = 0.5$ to 0.8)	Seifert et al. 1988

* multiple sensitization (not proved by inhibition-tests)

9 Allergenicity of Different Almond Varieties

Varieties / Subjects	Differences	References
<i>3 Almond Varieties</i> 8 almond sensitive patients	No significant differences in relative amounts and binding patterns of allergens (SDS-PAGE / immunoblot)	Bargman et al. 1992

10 Stability of Almond Allergens

Treatment	Effects	References
Almond extract (Storage) storage of water extract of almond meal	Incubation of a water extract in the presence of azide for about 12 days revealed degradation of the acidic polypeptides of amandin probably by endogenous proteinase(s)	Wolf & Sathe 1998
Almonds (Heat, Processing) commercial samples of almond butter, blanched, and roasted almonds	IgE-binding of protein extract from almond butter similar to that of raw almonds; blanching and roasting did not affect IgE binding of 45-50 kDa almond allergen, essentially reduced IgE binding of 70 kDa allergen, and eliminated IgE binding of 15 kDa allergen (SDS-PAGE immunoblot, 8 almond sensitive individuals)	Bargman et al. 1992
Almonds (Heat, pH) a) commercial samples of blanched almonds, roasted almonds, and almond paste b) moist heating of purified almond major protein at 121°C for 15 min c) incubation of almond major protein at pH 12.5 and 1.5-2.5	Immunoreactivity of protein extracts in comparison to purified almond major protein (polyclonal rabbit antibodies, noncompetitive ELISA): a) reactivity of blanched almonds, roasted almonds, and almond paste was respectively reduced by 50.0%, 56.6%, and 68.4% b) moist heat pretreatment reduced reactivity by 87% c) pH extremes (12.5 and 1.5-2.5) caused a 53% and 57% reduction in reactivity, respectively	Acosta et al. 1999
Almond protein isolate (Hydrolysis) Pepsin digestion of almond protein isolate in 0.1-M HCl at 37°C for 0-60 min (protein enzyme ratios from 50:1 to 1000:1)	Major polypeptides with 38-42 kDa completely hydrolyzed within 2 min, with 20-22 kDa within 5 min; digestion products in the range of 15-36 kDa and 15-20 kDa are hydrolyzed after 45-60 min (SDS-PAGE)	Sze-Tao & Sathe 2000

11 Allergen Sources

Reported Adverse Reactions	References
Essence in Curry Severe allergic reactions in a 30 year old woman after ingestion of almond traces from an essence in curry (1)	(1) Ewan 1996
Various Foods Registration of adverse reactions to foods in Sweden show that 51 out of 77 cases were the result of inadequate labelling; 3 of these cases were due to almond (1)	(1) Kjelkevik et al. 1997

Allergens in Food Products	Content / Products	References
Almonds in Cereals commercial breakfast cereals	Detection of almond major protein by competitive ELISA inhibition (rabbit polyclonal antibody)	Acosta et al. 1999
Chocolate-coated Peanuts retail samples with undeclared almond content	2 of 4 samples contained 4 and 57 mg/kg almond in whole samples of chocolate-coated peanuts (ELISA, polyclonal antibodies specific for whole almond protein extract)	Hlywka et al. 2000

<p>Almond Oils 4 Commercially available almond oils (serum pool from 17 peanut and/or nut allergic patients)</p>	<p>IgE-binding potencies: blend of unrefined and refined oil (90 / 190°C max. processing temperature) > unrefined oil (57°C) > 2 refined, bleached, and deodorized oils (230-260°C) (dot immunoblot) Protein contents of unrefined oils 62 µg/mL, 2 refined oils: 2.2 and 17 µg/mL, and blended oil 13 µg/mL</p>	<p>Teuber et al. 1997</p>
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12 Food Allergen Labelling

Food Allergen	Labelling / Regulation Status	References
<p>International Regulations Tree nuts* and products of these</p>	<p>mandatory labelling of prepackaged food / advisory status (1)</p>	<p>(1) Codex Alimentarius Commission 1999</p>
<p>European Regulations Tree nuts* and products of these</p>	<p>labelling appropriate / recommendation (1)</p>	<p>(1) Bousquet et al. 1998</p>

* Including almond, brazil nut, cashew nut, hazelnut, pistachio, and walnut

13 References

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