

Allergen Data Collection:**Celery** (*Apium graveolens*)

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Abstract

IgE mediated reactions to celery are common in food allergic adults in Europe. Sensitization to celery is frequently associated with birch and/or mugwort pollinosis, hence the term "birch- mugwort- celery- syndrome" has been established. There is evidence that birch pollen and celery allergy are highly related in Central Europe, while celery allergy is most frequently related to mugwort pollen in Southern Europe. Moreover, allergies to carrot and spices, predominantly of the umbelliferous family, are highly associated to celery allergy. Celery can induce allergic reactions of immediate type from oral contact urticaria to anaphylactic shock. About 30% of patients with oral allergy syndrome are allergic to celery. Diagnostic tests like skin tests with raw celery and active allergen extracts have high positive predictive values, while the negative predictive values are low. Roots, also called tuber or celeriac, and sticks from the celery plant are used in nutrition and diagnostic procedures. Usually the frequency of sensitization to celery tuber is higher than to celery stick in celery allergic subjects. Celery tuber and stick are consumed as a raw or cooked vegetable and as a spice which is a common hidden allergen in various processed foods. Despite its high allergenic potency and at least partial thermostability celery and celery products are currently not included in mandatory labelling regulations for food allergens.

At least three groups of cross- reactive allergens have been identified in celery: 1. Bet v 1 homologous 16 kDa allergen (Api g 1) with IgE cross- reactivity to birch pollen, fruits, and vegetables (eg. apple and carrot), 2. The actin- binding panallergen profilin (Api g 4) with appr. 15 kDa, and 3. Allergens in the range of 30-70 kDa, including the recently described 55/58 kDa isoallergens (Api g 5) cross-reactive to birch pollen and mugwort pollen.

The present data collection reviews detailed information on the prevalence and symptoms of celery allergy as well as cross- reactivities, and molecular biological and allergenic properties of the major celery allergens in tabular form.

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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 Celery 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 Subjects with Atopic or Other Diseases

Country / Subjects	Allergy / Sensitivity	References
France 80 cases of food- related anaphylaxis (study period 1993-97)	celery and carrot 7.5% (reported to CICBAA databank)	European Commission 1998
France, Lyon a) 61 patients with mugwort pollen sensitivity b) from which 26 with birch pollen sensitivity	a) celery 59% b) celery 88% (RAST)	Vallier et al. 1988
France, Paris a) 24 patients with latex and pollen allergy b) 20 patients with latex allergy (no pollen allergy) c) 25 patients with pollen allergy (no latex allergy)	clinical symptoms SPT a) celery in 0% and 33% b) celery in 0% and 5% c) celery in 20% and 72%	Levy et al. 2000
France, Pierre Benite a) 580 patients with adverse reactions to food b) 60 cases of anaphylaxis (study period 1984-92)	a) celery 30% (RAST) b) celery 30%	Andre et al. 1994
Germany, Berlin 167 pollen and food sensitive patients	celery 70% and 14% (SPT and case history)	Jankiewicz et al. 1996
Italy, Florence 54 episodes of food-dependent anaphylaxis in 44 children (age of 1 month to 16 years) (from 1994-1996)	celery 1.9%	Novembre et al. 1998
Italy, Genoa 132 pollen and food sensitive patients	celery 0.7% (self-reported)	Troise et al. 1992
Italy, Milan 262 fruit and/or vegetable allergic patients	celery 5-10% (clinical history)	Ortolani et al. 1988
Italy, Milan 100 fruit and/or vegetable allergic patients	celery 5% (clinical history)	Ortolani et al. 1989
Italy, Milan 196 adults with birch pollen allergy and oral allergy syndrome	celery 7% (clinical history)	Asero 1997
Netherlands 131 cases of food- induced anaphylaxis (from 1993-1997)	celery 6.1% (survey, reported to the TNO Nutrition and Food Research Institute)	European Commission 1998
Spain, Madrid 29 plant-derived food allergic patients	celery 3.4% (SPT)	Diez-Gomez et al. 1999
Sweden 55 cases of food- induced anaphylaxis (from 1994-1996)	celery 3.6% (Hospital Reports)	European Commission 1998
Sweden, Halmstad / Malmö a) 380 birch pollen allergic patients b) 103 patients without birch pollen allergy	a) celery 2% b) celery 0% (questionnaire)	Eriksson et al. 1982
Switzerland, Bern 22 patients with severe food-induced anaphylaxis (study period 1994-96)	celery 50%	Rohrer et al. 1998

Switzerland, Vaudois 111 patients with pollen- associated food allergy	celery 57% (RAST)	Bircher et al. 1994
Switzerland, Zurich 402 food allergic adults (study period 1978-87)	celery 43% (clinical history, diagnostic tests)	Wüthrich 1993
Switzerland, Zurich 383 food allergic patients (study period 1990-94)	celery 36% celery tuber 20% (spice) (clinical history, diagnostic tests)	Etesamifar & Wüthrich 1998
UK, London 100 patients with food intolerance	celery 1% (repeated challenge)	Lessof et al. 1980
USA, Boston, MA 279 adults with exercise- induced anaphylaxis (study period 1980-98)	celery 7% (reported trigger)	Shadick et al. 1999

1.2 Prevalence of Associated Allergies

Country / Subjects	Sensitivity / Allergy to	References		
Austria, Vienna 20 patients with mugwort- birch- celery- spice syndrome	paprika 73% pepper 95% (immunoblot)	Leitner et al. 1998a		
Italy, Milan 196 adults with birch pollen allergy and oral allergy syndrome	celery and carrot 83% (n=103) celery and fennel 73% (n=63) (concordance of allergy, clinical history)	Asero 1997		
Switzerland, Zurich 31 celery allergic patients (study period 1978-82, follow-up 1983)	mugwort pollen 87% carrots 52% caraway 26% parsley 16% fennel 13% green pepper 10% aniseed 3% (clinically relevant allergy)	Wüthrich & Hofer 1984		
Switzerland, Zurich 70 patients with celery and pollen allergy (birch and/or mugwort)	Spices from Apiaceae family (same as celery): aniseed, fennel, coriander, and cumin in >34%; Spices from unrelated families (red pepper, white pepper, ginger, nutmeg, cinnamon): positive in 3 of 11 patients (scratch test)	Stäger et al. 1991		
Switzerland, Zurich 22 patients with positive DBPCFC to celery		SPT	RAST	Ballmer-Weber et al. 2000 Lüttkopf et al. 2000
	birch pollen	91%	91%	
	alder pollen	86%		
	hazel pollen	82%		
	grass / rye pollen	55%	67%	
	ash pollen	36%		
	mugwort pollen	36%	73%	
	carrot		77%	

RAST	a)	b)	c)	d)	e)
celery stick	0%	45%	0%	17%	70%
celery tuber	0%	100%	0%	50%	100%
celery mix	0%	100%	0%	100%	100%
<i>Umbelliferae</i>	0%	9-18%	14-28%	33-50%	30-70%
<i>Labiatae</i>	0%	9%	0%	0%	20-30%
<i>Umbelliferae</i> : aniseed, dill, fennel, lovage					
<i>Labiatae</i> : basil, majoram, pot majoram, thyme					

Switzerland, Zurich
41 patients with sensitivity to
a) 7 birch pollen sensitive
b) 11 birch pollen and celery
c) 7 mugwort pollen
d) 6 mugwort pollen and celery
e) 10 birch, mugwort pollen and celery

[Wüthrich et al. 1992](#)

2 Symptoms of Celery Allergy

Symptoms & Case Reports	References
<p><u>systemic reactions</u> anaphylaxis (1, 4, 5, 6, 7, 9, 10), exercise-induced anaphylaxis (3, 8)</p> <p><u>symptoms on skin and mucous membranes</u> angioedema (2, 4, 6, 10, 16, 17), conjunctivitis (17), edema (15), flush (17), itch of ears (17), palmoplantar itch (17), pruritus (10), generalized pruritus (17), urticaria (2, 4, 6, 10, 15, 16, 17), contact urticaria syndrome (4)</p> <p><u>gastrointestinal symptoms</u> abdominal cramps (17), diarrhea (16), emesis (17), flatulence (17) itching in throat (16, 17), heartburn (17), swelling of lips (16), nausea (16, 17), vomiting (16), oral allergy syndrome* (12, 14, 16, 17)</p> <p><u>respiratory symptoms</u> asthma (10, 16), cough (17), dyspnoe (17), laryngeal edema (11, 13, 14), rhinitis (17), rhinoconjunctivitis (10, 17), general / not specified (6)</p> <p>* symptoms, which could be involved in oral allergy syndrome: local symptoms as intra-oral and lip-irritation, angioedema and systemic symptoms as rhino-conjunctivitis, urticaria-angioedema, asthma, and anaphylaxis (11)</p>	<p>(1) Forsbeck & Ros 1979 (2) Kauppinen et al. 1980 (3) Kidd et al. 1983 (4) Kremser & Lindemayr 1983 (5) Dechamp et al. 1984 (6) Pauli et al. 1985 (7) Rose & Altman 1985 (8) Silverstein et al. 1986 (9) Stricker et al. 1986 (10) Pauli et al. 1988 (11) Ortolani et al. 1988 (12) Ortolani et al. 1989 (13) Hoerler & Ukiwe 1992 (14) Jordan-Wagner et al. 1993 (15) Bonnin et al. 1995 (16) Jankiewicz et al. 1996, 1998 (17) Ballmer-Weber et al. 2000</p>

Percentage of Reactions

Symptoms / Ref.	(1)	(2)	(3)	(4)	(5)	(6)
Anaphylaxis	19%	15%	2.9%	20%	%	
Shock fragments	10%		2.9%			
Cutaneous						
Angio-oedema	29%		31%			14%
Contact urticaria			17%			
Urticaria	10%		5.7%		17%	
Urticaria / Angio-oedema		85%		90%		
Urticaria / flush / pruritus						23%
Oral allergy syndrome					87%	55%
Gastrointestinal					20%	14%
Diarrhea	6.5%		2.9%			
Respiratory		40%		35%		
Asthma	6.5%		8.6%		10%	
Dyspnoe	10%		20%			
Dyspnoe / cough						14%
Rhinitis / conjunctivitis	10%		8.6%			14%
No. of patients	31	20	35	20	30	22

(1) celery allergic patients (clinical history)

(2) patients with celery allergy and concomitant pollen allergy (mugwort, birch) (clinical history)

(3) celery allergic patients (clinical history)

(4) patients (14-49 years of age) with celery allergy (clinical history)

(5) adults with celery and pollen allergy (clinical history)

(6) after DBPCFC in celery allergic patients (13-55 years of age)

(1) [Wüthrich & Hofer 1984](#)

(2) [Pauli et al. 1985](#)

(3) [Wüthrich & Dietschi 1985](#)

(4) [Pauli et al. 1988](#)

(5) [Jankiewicz et al. 1998](#)

(6) [Ballmer-Weber et al. 2000](#)

Onset of Symptoms

Symptoms occurred after ingestion of celery within 30 min to 1 h in 46%, within 2-3 h in 8%, and >3 h in 46% of 13 celery allergic patients (1)

Symptoms of oral itching and eyelid angioedema in 2 patients within 4 and 6 min after open food challenge with 15 g of celery (2)

(1) [Kremser & Lindemayr 1983](#)

(2) [Ortolani et al. 1989](#)

Threshold for Elicitation of Symptoms

Quantities of 700 mg celery induced allergic symptoms in 48%, 1.9 g and 5.6 g in 10% each, 13.3 g in 5%, and 28.5 g in 29% of 21 celery allergic patients with positive DBPCFC (1)

(1) [Ballmer-Weber et al. 2000](#)

3 Diagnostic Features of Celery Allergy

Parameters / Subjects	Outcome	References
	Allergy to celery according to age groups:	
	years	(1)
		(2)
	<10	0%
		0%
	11-20	19%
		23%
	21-30	29%
		49%
	31-40	32%
		23%
	41-50	10%
		6%
	>50	10%
		0%
	(clinical history)	
Age at Manifestation		
31 celery allergic patients (1)		(1) Wüthrich & Hofer 1984
35 celery allergic patients (2)		(2) Wüthrich & Dietschi 1985

Gender of Patients 31 celery allergic patients (1) 35 celery allergic patients (2)	86% and 87% female, respectively (1, 2)	(1) Wüthrich & Hofer 1984 (2) Wüthrich & Dietschi 1985																														
RAST, Scratch Test 68 pollen allergic patients	72% concordance of RAST and scratch chamber test to celery	Halmeppuro et al. 1984																														
IgE birch pollen allergic patients with atopic dermatitis: a) responding (n=17) with worsening of atopic dermatitis within 48 h (no immediate symptoms observed) and b) non-responding (n=20) to DBPCFC with birch pollen related foods (carrot, celery, hazelnut, apple)	Celery specific serum IgE (RAST): a) 8.4 kU/L b) 3.1 kU/L (mean values)	Reekers et al. 1999																														
SPT, IgE and Clinical Relevance 31 celery allergic patients	Skin testing (scratch or prick) with fresh celery bulb was reliable, RAST was not sufficiently sensitive	Wüthrich & Hofer 1984																														
SPT, IgE and Clinical Relevance 35 celery allergic patients	Positivity of diagnostic tests: SPT with native celery- root 89%, scratch test with celery- salt 71%, intracutaneous test with commercial extract 64%, RAST with celery- sticks 66%	Wüthrich & Dietschi 1985																														
a) RAST and Clinical Relevance b) SPT and Clinical Relevance 4 patients with clinical history of celery allergy	a) RAST (specific IgE > 0.7 kU/L): positive results in 75% b) SPT with fresh food: positive results in 100%	Ortolani et al. 1989																														
SPT, IgE, and DBPCFC 32 patients with history of celery allergy (13-55 years of age, mean 32 years)	69% of patients were positive in DBPCFC, 4 of 8 non-responders reacted in open challenge, and 2 placebo-responders <table border="1"> <thead> <tr> <th></th> <th>a)</th> <th>b)</th> <th>c)</th> <th>PPT*</th> <th>RAST</th> </tr> </thead> <tbody> <tr> <td>sensitivity</td> <td>48%</td> <td>86%</td> <td>96%</td> <td>96%</td> <td>73%</td> </tr> <tr> <td>specificity</td> <td>88%</td> <td>13%</td> <td>25%</td> <td>0%</td> <td>38%</td> </tr> <tr> <td>PPV</td> <td>96%</td> <td>87%</td> <td>90%</td> <td>88%</td> <td>90%</td> </tr> <tr> <td>NPV</td> <td>19%</td> <td>11%</td> <td>43%</td> <td>0%</td> <td>17%</td> </tr> </tbody> </table> a) + b) SPT with commercial extracts c) SPT with self-prepared extract * prick-to-prick test with raw celery tuber		a)	b)	c)	PPT*	RAST	sensitivity	48%	86%	96%	96%	73%	specificity	88%	13%	25%	0%	38%	PPV	96%	87%	90%	88%	90%	NPV	19%	11%	43%	0%	17%	Ballmer-Weber et al. 2000
	a)	b)	c)	PPT*	RAST																											
sensitivity	48%	86%	96%	96%	73%																											
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PPV	96%	87%	90%	88%	90%																											
NPV	19%	11%	43%	0%	17%																											
IgE and DBPCFC (positive vs. negative) patients with history of celery allergy a) 22 with positive DBPCFC b) 4 with negative DBPCFC and positive open challenge c) 4 with negative DBPCFC and negative open challenge	No obvious differences in sensitization pattern between a) and b) in immunoblot and EAST; only 1 patient of c) had celery specific IgE (Api g 4 and glycoproteins)	Lüttkopf et al. 2000																														
SPT and IgE celery allergic patients	a) Positivity in EAST to native celery: 50% of SPT positive patients (n=34) b) Positivity in EAST to heated celery: 18% of SPT positive patients (n=11) 26% of SPT negative patients (n=35)	Jankiewicz et al. 1996																														
SPT, Extracts 12 (14) patients with OAS after eating celery	Positive reactions in SPT: 58% to fresh celery extracts 86% to commercial extracts	Asero 1997																														

<p>SPT, RAST, Extracts, rApi g 1</p> <p>a) 24 patients with celery and birch pollen allergy from Davos, Switzerland</p> <p>b) 12 patients with celery allergy and mugwort pollen sensitivity from Montpellier, France</p>	<p>Positive reactions in skin prick-to-prick test and SPT, respectively:</p> <p>a) 100% to fresh celery 100% to commercial extracts 100% to recombinant Api g 1</p> <p>b) 92% to fresh celery 25% to commercial extracts 17% to recombinant Api g 1</p> <p>Positive reactions in RAST::</p> <p>a) 67% to commercial extracts</p> <p>b) 45% to commercial extracts</p>	<p>Hoffmann-Sommergruber et al. 1999a</p>									
<p>Immunoblot and Clinical Relevance</p> <p>a) 23 patients with celery allergy</p> <p>b) 15 patients with celery sensitivity (RAST) without clinical relevance</p>	<p>Sensitivity in SDS-PAGE immunoblot:</p> <table border="1" data-bbox="608 607 1134 734"> <thead> <tr> <th>Celery allergens</th> <th>a)</th> <th>b)</th> </tr> </thead> <tbody> <tr> <td>15 kDa allergen</td> <td>74%</td> <td>73%</td> </tr> <tr> <td>46-60 kD allergens</td> <td>30%</td> <td>60%</td> </tr> </tbody> </table>	Celery allergens	a)	b)	15 kDa allergen	74%	73%	46-60 kD allergens	30%	60%	<p>Bauer et al. 1996</p>
Celery allergens	a)	b)									
15 kDa allergen	74%	73%									
46-60 kD allergens	30%	60%									
<p>Mugwort Sensitization, Severity of Symptoms</p> <p>22 patients with positive DBPCFC to celery</p>	<p>Positivity to mugwort pollen (SPT):</p> <p>a) 60% of patients with systemic reactions to celery</p> <p>b) 16% of patients with pure oral allergy syndrome</p>	<p>Ballmer-Weber et al. 2000</p>									

4 Therapy of Celery Allergy

Treatment *	Outcome	References
<p>Oral Desensitization</p> <p>with commercial celery and parsley extracts: 1 adult with celery- carrot-mugwort- spice- syndrome, symptoms of urticaria, dyspnoe, vomiting, and collapse after ingestion of raw fruits and vegetables (especially celery) and spices</p>	<p>Daily administration of diluted mixed extract of increasing doses, maintenance dose administered 3 times per week, length of therapy approximately 3 years, after therapy parsley and celery were tolerated as spices, side effects of earlobe erythema and occasional diarrhea occurred</p>	<p>Wüthrich & Hofer 1986</p>
<p>Subcutaneous Desensitization</p> <p>with 2 commercial extracts (5 grasses, cereals, mugwort and ribwort / birch and alder): 1 adult with suspected celery allergy and symptoms of allergic rhinitis, generalized urticaria, angioedema, and pruritus</p>	<p>After 3 years of subcutaneous desensitization no symptoms of pollinosis or food allergy occurred</p>	<p>Wüthrich & Hofer 1986</p>

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

5 Composition of Celery Tuber

5.1 Distribution of Nutrients (raw vegetable)

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

Nutrients: Content per 100 g		
Energy 78 kJ (18 kcal)	Selenium 1-10 µg	Thr 45 mg
Water 88.6 g		Trp 12 mg
Protein 1.6 g	Vitamins	Tyr 25 mg
Lipid 0.3 g	Carotin 15 µg	Val 75 mg
Carbohydrate 2.3 g	Vitamin K 100 µg	
Fiber 4.2 g	Vitamin B1 35 µg	Carbohydrates
Minerals 0.9 g	Vitamin B2 70 µg	Fructose 100 mg
	Nicotinamide 900 µg	Sucrose 1710 mg
Minerals	Pantothenic acid 510 µg	Starch 440 mg
Sodium 75 mg	Vitamin B6 200 µg	
Potassium 320 mg	Folic acid 7 µg	Lipids
Magnesium 9 mg	Vitamin C 8 mg	Palmitic acid 65 mg
Calcium 70 mg		Stearic acid 4 mg
Manganese 150 µg	Amino Acids	Oleic acid 13 mg
Iron 530 µg	Arg 45 mg	Linolic acid 155 mg
Copper 20 µg	His 25 mg	Linoleic acid 17 mg
Zinc 310 µg	Ile 50 mg	
Phosphorus 80 mg	Leu 75 mg	Others
Chloride 150 mg	Lys 75 mg	Oxalic acid 6800 µg
Fluoride 14 µg	Met 18 mg	Purines 30 mg
Iodine 3 µg	Phe 45 mg	

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

5.2 Proteinfraction

Proteins / Glycoproteins	Amount
Profilin (Api g 4)	33 µg / 100 g raw celery tuber (yield after 4 step purification) (1)

References: (1) [Vallier et al. 1992](#)

6 Allergens of Celery

Proteins / Glycoproteins	Allergen Nomenclature	References
Bet v 1 - homologous Protein [16 kDa]	Api g 1.0101 Api g 1.0201	Breiteneder et al. 1995 , Ebner et al. 1995 , Vieths et al. 1995 , Hoffmann-Sommergruber et al. 2000
Chlorophyll a/b Binding Protein **	Api g 3*	Scheiner et al. 1997
Celery Profilin [15 kDa]	Api g 4	Vallier et al. 1992 , van Ree et al. 1992 , Ebner et al. 1995 , Vieths et al. 1995 , Scheurer et al. 2000
55/58 kDa Allergen	Api g 5	Ganglberger et al. 2000
Allergens: >30 kDa (CCD, cross-reactive carbohydrate determinants)		Vieths et al. 1994 , Jankiewicz et al. 1998 , Fötisch et al. 1999 , Lüttkopf et al. 2000
2 Allergens: appr. 15 kDa		Vallier et al. 1988
Allergens: 15, 25, 36, and 60 kDa		Jordan-Wagner et al. 1993
Allergens: 15, 46-60 kDa		Bauer et al. 1996
60 kDa Allergen		Heiss et al. 1996 , Grote et al. 1998

* proposed name not listed in WHO/IUIS Allergen Nomenclature ([Larsen & Lowenstein 2000](#))

** probably a minor allergen, clinical relevance unknown

6.1 Sensitization to Celery Allergens

Country / Subjects	Sensitization			References
Austria, Vienna 17 birch pollen allergic patients with celery sensitivity	15 kDa allergen (Api g 1) in 76% 13-14 kDa allergen (Api g 4) in 24 % (SDS-PAGE immunoblot)			Ebner et al. 1995
France, Lyon 36 patients with celery sensitivity	15 kDa allergen (probably Api g 4) in 58% high Mr bands in 63% any allergen band in 92% (SDS-PAGE immunoblot)			Vallier et al. 1988
France, Montpellier 12 patients with celery allergy (clinical history) and mugwort pollen sensitivity (SPT)	Allergens	immunoblot	SPT	Hoffmann-Sommergruber et al. 1999a
	nApi g 1	in 0%		
	rApi g 1	in 0%	in 17%	
	rBet v 1	in 0%		
	multiple celery proteins (other than Api g 1)	in 67%		
Germany, Berlin a) 60 celery sensitive patients b) 30 celery and pollen allergic patients	Allergens from celery tuber:			a) Jankiewicz et al. 1996 b) Jankiewicz et al. 1998
	Allergens	a)	b)	
	Api g 1	in 33%	80%	
	Api g 4	in 17%	23%	
	multiple bands (carbohydrate epitopes)	in 32%	27%	
other	in 10%			
	(SDS-PAGE / immunoblot)			

Germany, Berlin 12 apple and celery allergic patients	Carbohydrate epitopes on allergens > 30 kDa (periodate treatment, immunoblot, EAST inhibition)			Vieths et al. 1994
Netherlands, Amsterdam 401 sera with IgE against pollen and/or vegetable foods	celery profilin (Api g 4) in 18%			van Ree et al. 2000
Switzerland, Davos 24 patients with celery and birch pollen allergy (clinical history)	Allergens	immunoblot	SPT	Hoffmann-Sommergruber et al. 1999a
	nApi g 1	in 71%		
	rApi g 1	in 67%	100,00 %	
	rBet v 1	in 100%		
Switzerland, Zurich 22 celery allergic patients (DBPCFC positive)	Allergens	immunoblot		Lüttkopf et al. 2000
	Api g 1	59%		
	CCD (cross-reactive carbohydrate determinants), >45 kDa	55%		
	Api g 4	23%		

* for patients designated with celery sensitivity the history of celery allergy may be unknown

6.2 Properties of Bet v 1 - homologous Protein (Api g 1)

6.2.1 Molecular Biological Properties

Bet-v-1-homologous Protein	References																					
Allergen Nomenclature Api g 1	(1) Larsen & Lowenstein 2000																					
Isoallergens and Variants 2 isoallergens designated Api g 1.0101 and Api g 1.0201 sharing 72% aa similarity (1, 3) (BLAST at NBCI: 49% aa sequence identity and 65% similarity) 4 isoallergens in 2D-PAGE immunoblot (2)	(1) Breiteneder et al. 1995 (2) Schöning et al. 1995 (3) Hoffmann-Sommergruber et al. 2000																					
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6.2.2 Allergenic Properties

<p>Bet v 1 - homologous Protein</p>	<p>References</p>
<p>Frequency of Sensitization IgE-binding to Api g 1 in 33-100% of patients (1)</p>	<p>(1) see 6.1 Sensitization to Celery Allergens</p>
<p>Allergenicity of recombinant Api g 1 (1) All 10 sera from celery allergic patients bound to natural and recombinant Api g 1 with comparable intensities (immunoblot); complete inhibition of IgE binding to natural Api g 1 by rApi g 1 and rBet v 1, only reduced inhibition by rApi g 1 to natural Bet v 1 (serum pool, immunoblot inhibition); (2) 24 celery allergic and Api g 1 sensitized patients: a) Equal diagnostic potency (100% positivity) of commercial crude celery extract, native celery tuber and rApi g 1 in skin testing (SPT, skin prick-to-prick test) b) 16 sera showed IgE binding to Api g 1 in SDS-PAGE immunoblot, 2 sera detected native Api g 1 without reactivity to rApi g 1 indicating the presence of additional isoforms in native Api g 1 (3) 22 celery allergic patients (DBPCFC positive): 13 sera bound to natural and rApi g 1 in SDS-PAGE immunoblot (3 sera weaker binding to natural Api g 1 than to rApi g 1) and to rApi g 1 in EAST; inhibition of IgE binding from 1 patient's serum to rApi g 1 by native celery extract and rApi g 1 and to native Api g 1 from celery extract by rApi g 1 (immunoblot)</p>	<p>(1) Breiteneder et al. 1995 (2) Hoffmann-Sommergruber et al. 1999a (3) Lüttkopf et al. 2000</p>

<p>Allergenicity of recombinant Api g 1 isoforms Purified recombinant isoform Api g 1.0201: recognized by 10 sera from celery allergic patients, yet with weaker IgE-binding capacity as compared to rApi g 1 (Api g 1.0101) (SDS-PAGE immunoblot) (1) In immunoblot inhibition: IgE-binding to Api g 1.0201 not inhibited by rApi g 1 (Api g 1.0101), only weak inhibition by rBet v 1a, complete inhibition by natural Bet v 1 (1)</p>	(1) Hoffmann-Sommergruber et al. 2000
<p>Stability of Api g 1 Allergenic activity sensitive to heat treatment of celery tuber</p>	(1) see 9 Stability of Celery Allergens

6.3 Properties of Chlorophyll a/b Binding Protein

6.3.1 Molecular Biological Properties

Chlorophyll a/b Binding Protein	References
Allergen Nomenclature Api g 3 (proposed name)	(1) Scheiner et al. 1997
Molecular Mass 24.8 kDa	(not published)
Isoelectric Point pI 4.87	(not published)
<p>Amino Acid Sequence, mRNA, and cDNA</p> <p>Api g 3</p> <p>GenBank: Z75663</p> <p>Amino Acids 264</p> <p>mRNA 963 bp</p> <p>cDNA</p>	<p>(1) Hoffmann-Sommergruber et al. (GenBank)</p> <p>(2) Scheiner et al. 1997</p>
<p>recombinant Protein</p> <p>Expression in cDNA library: Api g 3 cloned after selection of IgE-binding clone from celery cDNA expression library (1)</p>	(1) Scheiner et al. 1997
<p>Biological Function / Localization</p> <p>In chloroplasts associated with the light- harvesting complex (1)</p>	(1) Scheiner et al. 1997
<p>Sequence Homology</p> <p>80-90% aa sequence identities to chlorophyll a/b binding proteins from white mustard, tomato, soybean, spinach, potato, barley, cucumber, garden pea, maize, rice, and wheat (1)</p>	(1) BLAST at NCBI

6.3.2 Allergenic Properties

Chlorophyll a/b Binding Protein	References
<p>Frequency of Sensitization</p> <p>Probably a minor allergen (IgE-binding in <50% of patients), apart from IgE-screening of the cDNA library the frequency of IgE binding has never been tested in a larger group of patients (2)</p>	<p>(1) see 6.1 Sensitization to Celery Allergens</p> <p>(2) Scheiner et al. 1997</p>

6.4 Properties of Celery Profilin

6.4.1 Molecular Biological Properties

Celery Profilin	References
Allergen Nomenclature Api g 4	(1) Larsen & Lowenstein 2000
Isoallergens and Variants Double band in SDS-PAGE (1, 2)	(1) Vallier et al. 1992 (2) Jankiewicz et al. 1998
Molecular Mass calculated: 14.3 kDa (3) SDS-PAGE: 15 kDa (1), 15-16 kDa (2)	(1) Vallier et al. 1992 (2) Jankiewicz et al. 1998 (3) Scheurer et al. 2000
Isoelectric Point calculated: pI 4.54 (2) 2D-PAGE: pI 5.80 - 5.90 (1)	(1) Vallier et al. 1992 (2) Scheurer et al. 2000
Amino Acid Sequence, mRNA, and cDNA	
Profilin	
SWISS-PROT:	
GenBank: AF129423	(1) Scheurer et al. 2000
Amino Acids 133	
mRNA 405 bp	
cDNA (open reading frame) 399 bp	
recombinant Protein <u>Expression in <i>Escherichia coli</i>:</u> PCR amplification of cDNA and expression of rApi g 4 in <i>E.coli</i> BL21DE3 using a modified pET-30a vector (1)	(1) Scheurer et al. 2000
Biological Function Profilin family (1)	(1) Vallier et al. 1992
Sequence Homology aa sequence identities to birch pollen profilin (Bet v 2) 80%, soybean profilin (Gly m 3) 78%, wheat profilin 78%, maize profilin 77%, kidney bean 76%, and barley profilin 75% (1, 2) aa sequence identity to human profilin: 33% (2)	(1) BLAST at NBCI (2) Scheurer et al. 2000

6.4.2 Allergenic Properties

Celery Profilin	References
Frequency of Sensitization IgE-binding to profilin in appr. 23-58% of patients (1)	(1) see 6.1 Sensitization to Celery Allergens
IgE-Binding Mimotope A synthetic peptide (CAISGGYPVC) defined by phage display (using random nonapeptide libraries screened with anti- profilin antibodies from an exclusively profilin allergic patient) inhibited IgE binding to celery tuber profilin (immunoblot). This peptide is considered to mimic a common conformational IgE epitope of profilins (1)	(1) Leitner et al. 1998b

Allergenicity of recombinant Api g 4

(1) 22 celery allergic patients (DBPCFC positive): 5 sera bound to natural and rApi g 4 in SDS-PAGE immunoblot and to rApi g 4 in EAST; inhibition of IgE binding from 1 patient's serum to rApi g 4 by native celery extract and rApi g 4 and to native Api g 4 from celery extract by rApi g 4 (immunoblot)

(2) 23% of 13 celery allergic patients (DBPCFC positive) and 88% of 8 birch profilin (Bet v 2) reactive sera reacted to rApi g 4 (immunoblot); IgE binding to rApi g 4 completely inhibited by celery extract in 9 sera and nearly completely by rBet v 2 in 2 sera; partial inhibition by rBet v 2 in 7 sera (immunoblot inhibition); complete inhibition of IgE binding to natural Api g 4 by rApi g 4 (2 sera and pooled serum, immunoblot inhibition); EAST inhibition with 1 serum (rApi g 4 vs. rBet v 2); Similar potencies of rApi g 4 and rBet v 2 in histamine release from basophils from 1 patient

- (1) [Lüttkopf et al. 2000](#)
 (2) [Scheurer et al. 2000](#)

6.5 Properties of 55/58 kDa Proteins (Api g 5)**6.5.1 Molecular Biological Properties**

55/58 kDa Proteins	References
Allergen Nomenclature Api g 5	(1) Larsen & Lowenstein 2000
Isoallergens and Variants At least 2 isoallergens by SDS-PAGE (1)	(1) Ganglberger et al. 2000
Molecular Mass SDS-PAGE: 2 allergens: 55 kDa and 58 kDa (1)	(1) Ganglberger et al. 2000
Isoelectric Point	
Amino Acid Sequence, mRNA, and cDNA Api g 5 SWISS-PROT: P81943 GenBank: PIR: Amino Acids 18 N-terminal aa mRNA cDNA	(1) Ganglberger et al. 2000
Other Properties Reactive to monoclonal mice antibodies against birch pollen and to polyclonal rabbit antibody against a mugwort pollen allergen (formerly Art v 1) (1)	(1) Ganglberger et al. 2000

6.5.2 Allergenic Properties

55/58 kDa Proteins	References
Frequency of Sensitization IgE-binding to 30-70 kDa allergens in 32-63% of patients (1)	(1) see 6.1 Sensitization to Celery Allergens

7 Isolation & Preparation

Extract / Purified Allergens	Methods	References
Protein extract	Grinding of raw piece-cut celery tuber in Tris/HCl buffer pH 7.6 (containing benzamidine, EDTA, and phenylmethyl- sulphonyl- fluoride), filtration, centrifugation, and precipitation by adding ammonium sulphate up to 75% saturation; resolubilization in Tris/HCl buffer pH 7.6 and dialysis; extract defatted with ethyl ether	Vallier et al. 1992
Protein extract	Low temperature extraction method: raw celery tuber homogenized in acetone (-40°C), precipitates washed, filtered, lyophilized and water extracted	Vieths et al. 1992
Protein extract	Protein extraction from celery tuber with potassium phosphate buffer pH 7.0 (containing polyvinylpyrrolidone, EDTA, and diethylthiocarbamic acid, sodium azide), centrifugation, filtration and dialysis, storage after lyophilization -20°C	Bauer et al. 1996
Protein extract	Celery tuber ground in liquid nitrogen (1) or frozen in liquid nitrogen and homogenized (2), protein extraction with potassium phosphate buffer (1) or phosphate buffered saline pH 7.4 (2) at 4°C, centrifugation, filtration, dialysis, and lyophilization	(1) Ganglberger et al. 2000 (2) Ballmer-Weber et al. 2000
Profilin (Api g 4)	Isolation from protein extract by 4 chromatographic steps: IEC (with DEAE) followed by SEC (with Sephacryl S200), and preparative anion exchange HPLC (DEAE) followed by exclusion- diffusion HPLC (Protein PAK SW 300)	Vallier et al. 1992
Profilin (Api g 4)	Isolation from protein extract by affinity chromatography with a poly- L-prolin column	Vallier et al. 1992 Vieths et al. 1995
55/58 kDa allergen (Api g 5)	Separation of celery extract by IEC (Mono Q HR column)	Ganglberger et al. 2000
63 kDa allergen (Api g 5)	Preparative SDS-PAGE of celery extract followed by gel elution	Ganglberger et al. 2000

8 Cross-Reactivities

Cross-Reacting Allergens	Subjects / Methods	References
Celery: (pollen) mugwort and birch pollen	13 celery allergic patients: Cross- reactivity between stick celery and mugwort and birch pollen (RAST inhibition)	Kremser & Lindemayr 1983
Celery: (pollen, apple) mugwort and birch pollen, apple	Cross- reactivity between celery tuber, birch pollen, and apple (RAST inhibiton)	Halmeppuro et al. 1984
Celery: (pollen) mugwort and birch pollen	20 celery and pollen allergic patients: Cross- reactivity in RAST inhibiton	Pauli et al. 1985
Celery: (pollen, fennel) significant associations: celery and mugwort pollen, celery and fennel *	262 fruit and/or vegetable allergic patients (clinical history, SPT, RAST)	Ortolani et al. 1988
Celery, Profilin: (pollen) birch and mugwort profilin (15 kDa)	Sera reactive to 15 kDa celery allergen: Inhibition of IgE binding to birch and mugwort pollen profilins (15 kDa each) by celery extract (1) and celery profilin (2) and to celery profilin by recombinant birch pollen profilin (2) (immunoblot inhibition)	Vallier et al. 1988 Vallier et al. 1992

Celery: (pollen) rye grass profilin (12 kDa)	Serum from 1 patient with allergic rhinitis and atopic dermatitis related to vegetable foods and pollen: inhibition of IgE-binding to rye grass profilin by celery extract (RAST), detection of celery profilin at 12 kDa (SDS-PAGE immunoblot)	van Ree et al. 1992
Celery (Api g 1): (birch pollen) birch pollen (Bet v 1)	7 Bet v 1 and Bet v 2 sensitive patients (pooled serum): significant inhibition of IgE- binding to 15 kDa allergen (Api g 1) by rBet v 1, no inhibition of binding to 14 kDa allergen (Api g 4) (immunoblot inhibition)	Ebner et al. 1995
Celery (Api g 4): (birch pollen) birch pollen (Bet v 2 profilin)	7 Bet v 1 and Bet v 2 sensitive patients (pooled serum): complete inhibition of IgE- binding to 14 kDa allergen (Api g 4) by rBet v 2, no inhibition of binding to 15 kDa allergen (Api g 1) (immunoblot inhibition)	Ebner et al. 1995
Celery allergens: (pollen) birch and mugwort pollen, Api g 1, Api g 4	16 kDa celery allergen (Api g 1) cross- reactive to Bet v 1 detected by 6/8 of patients with a birch pollen / celery sensitivity; 15 to 16 kDa double band (celery profilin, Api g 4) detected by 6/16 patients with mugwort pollen / celery and birch pollen / mugwort pollen / celery sensitivities (SDS-PAGE immunoblot, immunoblot inhibition)	Vieths et al. 1995
Celery: (pollen) birch and mugwort pollen	Pooled sera from patients with celery allergy: Inhibition of IgE binding to 46-60 kD celery allergens by birch and mugwort pollen (immunoblot inhibition)	Bauer et al. 1996
Celery: (pollen) 60 kDa mugwort allergen (formerly Art v 1)	Patients with food and pollen allergy: inhibition of IgE-binding to appr. 40-70 kDa celery allergens by 60 kDa mugwort allergen in 2 of 3 patients (SDS-PAGE inhibition), 2-40% reduction of IgE-binding to celery proteins by 60 kDa mugwort allergen in 3 patients (RAST inhibition)	Heiss et al. 1996
Celery: (birch pollen) 35 kDa birch pollen allergen and Bet v 1	Sera from birch pollen allergic patients reactive to 35 kDa allergen: IgE binding to celery extract inhibited by 35 kDa allergen and Bet v 1 from birch pollen (EAST inhibition)	Wellhausen et al. 1996
Celery extract, rApi g 1: (pollen) birch pollen, rBet v 1, rBet v 2 profilin, timothy grass pollen extract; 21 patients with clinical relevant allergy to pollen and plant-derived food	Mixture of rBet v 1 and rBet v 2 inhibited IgE-binding to 10-14 kDa (profilin related) and 17-21 kDa (Bet v 1 related) celery allergens, timothy grass pollen inhibited IgE-binding to 10-14 kDa and 30-100 kDa allergens from celery; only weak inhibition of IgE-binding to Bet v 1 by rApi g 1 (immunoblot inhibition); 79% (2-100%) inhibition of IgE-binding to celery extract by mixture of rBet v 1 and rBet v 2 and 89% (4-100%) by mixture of rBet v1, rBet v 2, and timothy pollen extract (9 sera) (RAST inhibition)	Kazemi-Shirazi et al. 2000
Celery: (pollen, fruits) birch pollen, apple and cherry extracts; rBet v 1 (birch pollen), and Bet v 1 homologous allergens rApi g 1 (celery), rMal d 1 (apple), and rPru a 1 (cherry)	a) 4 birch pollen and cherry allergic patients: No inhibition of IgE-binding by rApi g 1 to neither of the extracts or rBet v 1 and rPru a 1 (immunoblot inhibition estimated according to band intensities) b) Max. inhibition of IgE binding to rApi g 1 by rMal d 1 and rPru a 1 <20% and by rBet v 1 >90%, estimated allergenic potencies: rBet v 1 >> rMal d 1, rPru a 1 > rApi g 1 (EAST inhibition, 10 cherry and/or celery allergic patients) c) Results indicate different epitopes of Api g 1 and fruit allergens (Mal d 1, Pru a 1)	Scheurer et al. 1999

<p>Celery: (pollen, fruits) a) birch pollen b) mugwort pollen c) lychee fruit d) carbohydrate moieties</p>	<p>IgE binding to celery extract in celery allergic patients (DBPCFC positive): a) >90% max. inhibition (3 sera, EAST inhibition) b) >75% max. inhibition in 2 from 3 sera (EAST inhibition) c) About 90% max. inhibition in 2 from 3 sera (EAST inhibition) d) Complete inhibition of IgE binding to celery allergens >40 kDa by bromelain glycopeptide MXF (2 sera, immunoblot inhibition)</p>	<p>Lüttkopf et al. 2000</p>
<p>Celery: (carrot) stick celery, carrot</p>	<p>Cross- reactivity between stick celery and raw carrot; detection of 17 kDa allergen in celery and carrot (RAST inhibition, immunoblot inhibition)</p>	<p>Helbling et al. 1993</p>
<p>Celery: (carrot) Dau c 1 from carrot, Api g 1</p>	<p>Pooled sera from 6 carrot allergic patients: Reduction of IgE-binding to native Dau c 1 and complete inhibition to rDau c 1.2 by rApi g 1 from celery (immunoblot inhibition)</p>	<p>Hoffmann-Sommergruber et al. 1999b</p>
<p>Celery: (fruits, vegetables) carrot, cucumber, watermelon</p>	<p>6 patients sensitive to celery, carrot, cucumber and/or watermelon (SPT, EAST): Cross- reactivity between all 4 foods; detection of 15 kDa allergen in all foods (RAST inhibition, immunoblot inhibition)</p>	<p>Jordan-Wagner et al. 1993</p>
<p>Celery: (tomato) tomato</p>	<p>6 Pollen and tomato sensitized patients: 51-85% inhibition of IgE binding to tomato extract by celery extract (EAST inhibition)</p>	<p>Petersen et al. 1996</p>
<p>Celery: (apple) apple</p>	<p>16 celery and/or apple allergic patients: Detection of Bet v 1 and Bet v 2 homologous allergens in celery and apple extracts; inhibition of IgE binding to celery extract by apple extract and vice versa, allergenic potencies: apple > celery (ELISA and immunoblot inhibition)</p>	<p>Steurich & Feyerabend 1996</p>
<p>Celery: (spices) pepper and paprika</p>	<p>Pooled sera from 5 patients with celery- birch- mugwort- spice syndrome: Significant inhibition of IgE binding to pepper and paprika allergens by celery tuber extract and vice versa; no inhibition to pepper and paprika allergens by rBet v 1 and rBet v 2 (immunoblot inhibition)</p>	<p>Leitner et al. 1998a</p>
<p>Celery: (carbohydrate epitopes) glycopeptide bromelain</p>	<p>Pooled serum from 5 celery allergic patients: 78% and 8.6% inhibition of IgE binding to bromelain by celery extracts and rApi g 1, respectively (ELISA inhibition)</p>	<p>Jankiewicz et al. 1998</p>
<p>Celery: (carbohydrate epitopes) N-glycan from bromelain</p>	<p>7 celery allergic patients with IgE binding to N-glycan from bromelain: 22-100% maximal inhibition of IgE binding to celery by bromelain glycan (EAST inhibition); Inhibition of IgE binding to multiple bands >40 kD from celery by bromelain glycan (immunoblot inhibition); alpha 1,3-fucose key structure for IgE binding (chemical defucosylation)</p>	<p>Fötisch et al. 1999</p>

* multiple sensitization (not proven by inhibition-tests)

9 Stability of Celery Allergens

Treatment / Ripening	Effects	References
Celery (Heat) cooking	Sensitivity to raw and cooked celery (scratch chamber test, 13 celery allergic patients)	Kremser & Lindemayr 1983
Celery (Heat) boiled celery tubers (30 min), boiling water	70 patients with celery and pollen sensitivity (birch and/or mugwort) in SPT or intracutaneous test, positivity in SPT: 94% to raw celery tuber, 36% to cooked celery tuber, 8/13 to cooking water Celery-birch sensitive patients (n=13): negative or low RAST to heated celery extracts and to stick celery Celery-mugwort sensitive patients (n=6): positive RAST to heated celery extracts and high RAST values to stick celery	Wüthrich et al. 1990
Celery (Heat) microwaved celery tubers (750 W, 100°C)	a) Reactivity of 46 celery sensitive patients (1): 78% to raw celery, 43% to celery heated for 30 min (SPT and/or EAST); b) Reactivity of 30 celery and pollen allergic patients in EAST (2): 100% to raw celery, 67% to celery heated for 10 min, 57% to celery heated for 30 min; c) Api g 1 abolished after 10 min, profilin (Api g 4) after 30 min, and carbohydrate epitopes (allergens >30 / >35 kDa) were heat resistant (SDS-PAGE immunoblot) (1, 2)	(1) Jankiewicz et al. 1996 (2) Jankiewicz et al. 1998
Celery (Heat) microwaved celery tubers (30 min, 100°C)	Heating of celery tuber reduced allergenic activity of Api g 1, while semipurified heated Api g 1 retained immunoreactivity (SDS-PAGE immunoblot)	Vieths et al. 1998
Celery (Heat) celery tubers (30 min, 100°C)	a) 22 celery allergic patients (DBPCFC positive): 68% of sera bound to allergens from native celery and 27% to heated celery allergens (EAST) b) Api g 1 monosensitized patient: strong inhibition of IgE binding to native celery extract by rApi g 1, native celery extract, and birch pollen; no inhibition by heated celery extract (EAST inhibition) c) CCD (cross-reactive carbohydrate determinants) monosensitized patients: >75% max. inhibition of IgE binding to celery extract by heated celery extract (EAST inhibition)	Lüttkopf et al. 2000
Celery (preservation) preservation methods a) gamma-irradiation (total dose of 10 kGy) b) ultra high pressure (600 mPa / 20°C) c) commercially dried celery powder d) a high voltage impulse treatment	3 sera from celery sensitive patients with different specificity (to Api g 1, profilin or glycoproteins >30 kDa, respectively): Little changes (slight increase or decrease) in IgE binding for all 4 methods, none of the treatments resulted in loss of IgE binding (EAST); new allergen band with 18-19 kDa detected in irradiated celery tuber (SDS-PAGE immunoblot)	Jankiewicz et al. 1997 Vieths et al. 1997

Celery (Enzymic Hydrolysis) a) digestion with artificial gastric fluid (pepsin, cathepsin, and mucin, 2 h, 37°C) b) followed by hydrolysis with pancreatic enzymes (45 min, 37°C)	3 sera from celery sensitive patients: a) loss of celery bands >40kDa, strong IgE binding to hydrolyzed proteins (immunoblot) b) other proteins degraded with the exception of proteins at <20kDa and 38 kDa, strong reduction of IgE binding (immunoblot)	Vieths et al. 1997
Celery Extract (Deglycosylation) deglycosylation by periodate treatment	Celery allergic patients: Strong reduction of IgE binding to allergens > 30 / 35 kDa indicating carbohydrate epitopes, no difference in IgE binding to Api g 1 and Api g 4 (SDS-PAGE immunoblot, EAST inhibition) 8 from 12 sera showed IgE binding to bromelain glycopeptide (ELISA) (3)	(1) Vieths et al. 1994 (2) Jankiewicz et al. 1996 (3) Jankiewicz et al. 1998
Celery Extract (Deglycosylation) deglycosylation by periodate treatment	Celery allergic patients: No difference in IgE binding (SDS-PAGE immunoblot)	Bauer et al. 1996

10 Allergen Sources

Reported Adverse Reactions	References
Food / Food additives After ingestion of vegetable and as spice (1)	(1) see 2 Symptoms of Celery Allergy
Canned Celery Local and systemic allergic reactions in 1 patient after ingestion of canned celery preparation, positive SPT to raw celery and negative SPT to cooked celery	Bauer et al. 1996

11 Food Allergen Labelling

Food Allergen	Labelling / Regulation Status	References
International Regulations Celery and products of these	not demanded / advisory status (1)	(1) Codex Alimentarius Commission 1999
European Regulations Celery and celery products	not demanded / recommendation (1)	(1) Bousquet et al. 1998

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