

Allergen Data Collection - Update:

Rice (*Oryza sativa*)

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Rice (*Oryza sativa*)

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Abstract

Rice is a cereal grain belonging to the family of Gramineae. Cereals such as wheat, barley, rye, oats, maize, and rice are reported to elicit allergic reactions. Rice is the main and most important food taken every day in Eastern Asia. The prevalence of IgE-mediated rice allergy is about 10% in atopic subjects in Japan. The frequency of rice allergic reactions is much lower in Europe and the USA. Rice allergy is more prominent in adults than in children. Symptoms frequently associated with rice allergy are atopic dermatitis, eczema, and asthma. Anaphylactic reactions have been reported in severe cases.

*A multigene family of 14-16 kDa proteins presents the major allergens from rice seeds/grain, which show significant homology to the alpha-amylase / trypsin inhibitor family from wheat and barley. Other rice seed/grain allergens have been identified as a 33-kDa major allergen and a 60-kDa minor allergen. Most recently IgE binding cross-reactivity of rice proteins to a lipid-transfer protein from maize has been demonstrated, indicating the presence of this plant-pan allergen in rice. In addition to ingestive allergens rice presents an important aero-allergen (*Ory s 1*) belonging to the grass pollen group I allergens.*

In order to produce hypoallergenic rice several approaches have been undertaken. Less allergenic rice was obtained after different treatments with, for example proteases, alkali and/or hyperpressure. Several products proved to be effective for the diet of rice allergic individuals with atopic dermatitis.

Furthermore transgenic rice seeds with reduced expression level of the major 14-16 kDa allergens have been investigated.

An overview of prevalence data, symptoms, diagnostic and therapeutic features of rice allergy as well as molecular biological and allergenic properties of rice allergens is given in tabular form.

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1 Prevalence of Rice 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	Sensitivity to	References
Finland, Helsinki 16 wheat sensitive children with atopic dermatitis	rice 69% (SPT)	Varjonen et al. 1995
France, Pierre Benite 580 patients with adverse reactions to food	rice 17% (RAST)	Andre et al. 1994
Japan, Okinawa 127 atopic patients (bronchial asthma, allergic rhinitis and atopic dermatitis)	rice 12% (MAST)	Kosugi et al. 1992
Japan, Tokyo 39 children with positive food challenge	rice 8%	Iwasaki et al. 1994
Malaysia, Kuala Lumpur 148 adults with symptoms of nasal congestion and rhinorrhea	rice 30% (SPT)	Gendeh et al. 2000
Switzerland, Zurich 402 food allergic adults	rice 0.7%	Wüthrich 1993
Taiwan 312 asthmatic patients	rice pollen 9% (SPT), from which 35% were RAST positive	Tsai et al. 1990
USA, Davis, CA 464 male rice farmers	probably rice: 6-9% prevalence of respiratory symptoms	McCurdy et al. 1996
USA, Little Rock, AR appr. 700 atopic patients	rice < 1% (food challenge)	Helm & Burks 1996
USA, St. Louis, MO a) 1196 cereal allergic adults b) 118 cereal allergic children	a) rice 39% (SPT) b) rice 6% (SPT)	Lewis & Imber 1975
USA, OH 148 respiratory-allergic children with reproduced symptoms after food challenge	rice 2%	Ogle et al. 1980

1.2 Prevalence of Associated Allergies

Country / Subjects	Allergy / Sensitivity	References
Japan, Tokyo 161 asthmatic children	Cluster group: wheat, barley and rice (20 inhalants and 15 foods allergens, MAST, cluster analysis)	Iwasaki & Baba 1992

2 Symptoms of Rice Allergy

Symptoms & Case Reports	References
<p><u>systemic reactions</u> anaphylaxis (3, 12), exercise-induced anaphylaxis (7, 8)</p> <p><u>symptoms on skin and mucous membranes</u> atopic dermatitis (4, 11), eczema (1, 2), contact urticaria (5), in general (4)</p> <p><u>gastrointestinal symptoms</u> diarrhea (6), laryngeal edema (12), vomiting (6)</p> <p><u>respiratory symptoms</u> asthma (1, 2, 5, 9)</p> <p><u>other symptoms</u> atopic dermatitis with ocular complications (11), food protein-induced enterocolitis syndrome (10)</p>	<p>(1) Hoffman 1975 (2) Shibasaki et al. 1979 (3) Borchers et al. 1992 (4) Ikezawa et al. 1992b (5) Lezaun et al. 1994 (6) Cavataio et al. 1996 (7) Guinnepain et al. 1996 (8) Caffarelli et al. 1997 (9) Arai et al. 1998 (10) Sicherer et al. 1998 (11) Uchio et al. 1998 (12) Pastorello et al. 2000</p>

3 Diagnostic Features of Rice Allergy

Parameters / Subjects	Outcome	References
Age of Patients cereal allergic patients	Frequency of sensitivity to rice was six times higher in adults than in children (St. Louis, MO, USA)	Lewis & Imber 1975
Age and RAST rice allergic patients with atopic dermatitis	RAST positivity to rice was about 10% in up to 1-year-olds and reached the level of 30-50% after 2 years of age	Ikezawa et al. 1992b
RAST and Clinical Relevance a) 11 patients with overt symptoms from cereals b) 15 patients without overt symptoms from cereals	Groups a) and b) could not be distinguished by rice or other cereal specific RAST scores	Hoffman 1975
RAST and Clinical Relevance 184 rice, egg white or house dust mite allergic patients with atopic dermatitis	Correlation of clinical severity of atopic dermatitis and RAST score was the highest for rice allergens (0.52), (correlations for mites and egg white <0.15)	Ikezawa et al. 1992b
IgE, Histamine, Leukotriene B4 patients with atopic dermatitis, a) 70 with ocular complications, b) 146 without ocular complications	Significantly higher specific IgE for rice and wheat in a) than in b), Significantly elevated tear histamine and LTB4 levels in a) as compared to b) and controls	Uchio et al. 1998
Cytotoxic Leucocytes Test (CLT) 1824 CLTs with 23 food allergens	Rice one of 10 foods giving most often reactions in CLT	Ruokonen 1981
Lymphocyte Stimulation 5 rice allergic patients	Rice globulin and 2 globulin fractions revealed lymphocyte-stimulating activity	Shibasaki et al. 1979
PBMC Proliferation 2 rice pollen allergic patients	No significant differences between patients and controls in PBMC proliferation with rice pollen allergens	Tsai et al. 1990

<p>Isolated Rice Intolerance 4 children with isolated rice hypersensitivity</p>	<p>Symptoms: shock, vomiting, and diarrhea, occult blood in stools, immunologic tests negative; No symptoms during 6 weeks of a diet free of rice and flour, successive double-blind challenges caused severe shock in 3 of 4 infants, histologic alterations in intestinal mucosa after challenge</p>	<p>Cavataio et al. 1996</p>
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4 Therapy of Rice Allergy

Treatment*	Outcome	References
<p>Elimination Diet 25 patients with atopic dermatitis (RAST positive to rice)</p>	<p>Rice elimination diet (mean duration of elimination: 5.2 months): a) 36% showed improvement: rice and wheat specific RAST titers decreased b) 40% mild improvement c) 24% no improvement: total serum IgE and wheat specific RAST titers increased</p>	<p>Komatsu et al. 1990 Ikezawa et al. 1992b</p>
<p>Hypoallergenic Rice 1 rice allergic patient with asthma</p>	<p>Patient has been eating hypoallergenic rice with no bronchial asthma-induced attack</p>	<p>Arai et al. 1998</p>
<p>Hypoallergenic Rice patients with rice-associated atopic dermatitis</p>	<p>see section 11 Hypoallergenic Rice</p>	

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

5 Composition of Rice

5.1 Distribution of Nutrients (in polished seeds)

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

Nutrients: Content per 100 g		
Energy 1461 kJ (344 kcal) Water 12.9 g Protein 6.8 g Lipids 0.6 g Carbohydrate 77.8 g Fiber 1.4 g Minerals 0.5 g	Iodine 2 µg Selenium 10-70 µg	Met 170 mg Phe 390 mg Thr 280 mg Trp 90 mg Tyr 260 mg Val 490 mg
Minerals Sodium 6 mg Potassium 105 mg Magnesium 65 mg Calcium 6 mg Manganese 2 mg Iron 600 µg Copper 130 µg Zinc 500 µg Phosphorus 120 mg Fluoride 50 µg	Vitamins Vitamin E 70 µg Vitamin B1 60 µg Vitamin B2 30 µg Nicotinamide 1300 µg Pantothenic acid 630 µg Vitamin B6 150 µg Biotin 3 µg Folic acid 30 µg	Carbohydrates Sucrose 150 mg
	Amino Acids Arg 570 mg His 170 mg Ile 340 mg Leu 660 mg Lys 290 mg	Lipids Palmitic acid 110 mg Stearic acid 12 mg Oleic acid 220 mg Linolic acid 220 mg Linoleic acid 12 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
Soluble fractions	
Albumines (water-soluble)	10.8 %
Globulines (salt-soluble)	9.7 %
Prolamines (70%-ethanol soluble)	2.2 %
16 kDa Allergen (PBS-soluble fraction)	~ 1.5 % in seeds (300 µg / 20 mg)*
Insoluble fraction	
Glutelines	77.3 %

References: * [Tada et al. 1996](#)

6 Allergens of Rice

Seed Proteins / Glycoproteins	Allergen Nomenclature	References
<u>14-16 kDa Rice Allergens</u>		Matsuda et al. 1988 Urisu et al. 1991b
33-kDa Allergen		Nakase et al. 1998
60 kDa Allergen		Ikezawa et a. 1999
Major Allergens: 15.5, 16, 19 kDa		Urisu et al. 1991b
Major Allergens: 16, 25, 50, 90 kDa		Ikezawa et al. 1992a
Allergens: 12.5 and 28 kDa		Limas et al. 1990

Pollen Proteins / Glycoproteins	Allergen Nomenclature	References
<u>Major Pollen Allergen (Group I)</u>	Ory s 1	Xu et al. 1995
Allergens: 16, 26, and 32 kDa		Tsai et al. 1990

6.1 Sensitization to Rice Allergens

Country / Subjects	Sensitivity to	References
<i>Japan, Gunma</i> 5 rice allergic patients	Protein fractions: glutelin in a) 100% and b) 0% globulin in a) and b) 100% (a) RAST, (b) Lymphocyte Stimulation Test	Shibasaki et al. 1979
<i>Japan, Tokyo</i> 10 rice allergic patients with atopic dermatitis	Protein fractions: water-soluble in 50% salt-soluble in 90% ethanol-soluble in 30% acetic acid-soluble in 60% residue in 30% (RAST)	Watanabe et al. 1990a
<i>Japan, Toyoake</i> 31 rice allergic patients	16 kDa allergen in 100% (RAST)	Urisu et al. 1991a
<i>Japan, Toyoake</i> 32 rice allergic patients	19 kDa allergen in 56% 16 kDa allergen in 69% 15.5 kDa allergen in 97% 15-, 25-, 33-, 35-, 38-, 56- and 92-kDa allergens in 25-44% 32- and 40-kDa allergens in 13% 24-, 31-, 43-, 53-, 65-, 68-, 78-, 82- and 90-kDa allergens in <10% (SDS-PAGE / immunoblot)	Urisu et al. 1991b
<i>Japan, Yokohama</i> 15 rice allergic patients with atopic dermatitis	60 kDa allergen in 7% (1 patient) (SDS-PAGE / immunoblot)	Ikezawa et a. 1999
<i>Spain, Madrid</i> 4 cereal allergic patients	12.5 and 28 kDa allergen detected by pooled serum (SDS-PAGE / immunoblot)	Limas et al. 1990

6.2 14-16 kDa Rice Allergens

6.2.1 Molecular Biological Properties

14-16 kDa Rice Allergens	References																																																	
Allergen Nomenclature																																																		
Isoallergens and Variants At least 7 isoallergens of 14-16 kDa rice allergens which share > 67% amino acid sequence identity (2) fulfilling the definition of isoallergens of the WHO/IUIS Allergen Nomenclature Subcommittee (1)	(1) King et al. 1994 (2) Matsuda et al. 1996																																																	
Molecular Masses 14-16 kDa (SDS-PAGE) (1)	(1) Matsuda et al. 1991																																																	
Isoelectric Points pI 6-8 (1)	(1) Matsuda et al. 1991																																																	
Amino Acid Sequence, mRNA, and cDNA																																																		
<table border="1"> <thead> <tr> <th>Isoallergens</th> <th>RA14 (2)</th> <th>RA14B (3)</th> <th>RA14C (3)</th> <th>RA5 (2)</th> <th>RA5B (3)</th> <th>RA16 (3)</th> </tr> </thead> <tbody> <tr> <td>SWISS-PROT:</td> <td>Q01882</td> <td></td> <td></td> <td>Q01881</td> <td></td> <td></td> </tr> <tr> <td>GenBank:</td> <td>D11432</td> <td>D42139</td> <td>D42140</td> <td>D11430</td> <td>D42142</td> <td>D42141</td> </tr> <tr> <td>PIR:</td> <td>S31080</td> <td>S59922</td> <td>S59923</td> <td>S31078</td> <td>S59925</td> <td>S59924</td> </tr> <tr> <td>Amino Acids</td> <td>139</td> <td>166</td> <td>160</td> <td>131</td> <td>160</td> <td>157</td> </tr> <tr> <td>mRNA precursor</td> <td>618 bp</td> <td>643 bp</td> <td>606 bp</td> <td>618 bp</td> <td>631bp</td> <td>631 bp</td> </tr> <tr> <td>cDNA precursor</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	Isoallergens	RA14 (2)	RA14B (3)	RA14C (3)	RA5 (2)	RA5B (3)	RA16 (3)	SWISS-PROT:	Q01882			Q01881			GenBank:	D11432	D42139	D42140	D11430	D42142	D42141	PIR:	S31080	S59922	S59923	S31078	S59925	S59924	Amino Acids	139	166	160	131	160	157	mRNA precursor	618 bp	643 bp	606 bp	618 bp	631bp	631 bp	cDNA precursor							(1) Izumi et al. 1992 (2) Adachi et al. 1993 (3) Alvarez et al. 1995a (4) Oh et al. 1998
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mRNA precursor	636 bp				709 bp																																													
cDNA precursor		1286 bp	1603 bp	477 bp																																														
cDNA Library / Recombinant Proteins cDNA library: cDNA clones from maturing (1, 3, 4) and developing (5) seeds encoding rice allergens cDNA library screened with a rat anti-16 kD globulin protein polyclonal antibody, 5 independent cDNA clones were obtained which encoded 13-19 kD recombinant proteins identified by immunoblot analysis (6) Expression in Escherichia coli: Expression of 4 rice allergens (2)	(1) Adachi et al. 1993 (2) Alvarez et al. 1995b (3) Matsuda et al. 1996 (4) Nakamura & Matsuda 1996 (5) Oh et al. 1998 (6) Kim et al. 1999																																																	
Posttranslational Modifications Disulfide bonds: 5 disulfide bonds (1, 2)	(1) Nakase et al. 1998 (2) Izumi et al. 1999																																																	

<p>3D-Structure 3D-Structure prediction of 16-kDa allergen: compactly folded protein, small hydrophobic core, rich in sheet and helix structures (1)</p>	(1) Nakase et al. 1998
<p>Biological Function alpha-amylase/trypsin inhibitor family (1) Inhibitory activity toward human salivary alpha- amylase, not to bacterial alpha- amylase (2)</p>	(1) Alvarez et al. 1995a, b (2) Nakase et al. 1996
<p>Sequence Homology 14-16 kDa Rice allergens: sequence identities DNA > 80%, aa > 70% (2, 3) Alpha-amylase / trypsin inhibitors from wheat and barley: DNA sequence identities 20-40% (1, 3, 4, 5) Alpha-amylase / trypsin inhibitor family: well conserved 10 cystein residues region (1, 3) Castor bean storage protein: (1) Lipid transfer proteins: sequence of 25 C-terminal aa of 14-16 kDa rice allergen clones resembles plant lipid transfer proteins (2)</p>	(1) Izumi et al. 1992 (2) Alvarez et al. 1995a (3) Matsuda et al. 1996 (4) Nakamura & Matsuda 1996 (5) Nakase et al. 1998
<p>Localization Maturing rice seeds (2) Albumin / globulin protein fractions (1)</p>	(1) Matsuda et al. 1991 (2) Matsuda et al. 1996

6.2.2 Allergenic Properties

14-16 kDa Rice Allergens	References
<p>Frequency of Sensitization IgE-binding to 14-16 kDa rice allergens in 67-100% of patients (1) IgE-binding to 14-16 kDa isoallergens (2): a) 14-15.5 kDa allergen in 64% b) RA14 (~16 kDa) gene family, 3 isolated fractions: 41% (for 1 fraction) and 29% (other 2 fractions) c) RA17 (14-15.5 kDa) in 29% (17 rice allergic patients, RAST)</p>	(1) see 6.1 Sensitization to Rice Allergens (2) Nakase et al. 1996

6.3 Major Pollen Allergen (Grass Group I)

6.3.1 Molecular Biological Properties

Major Pollen Allergen	References
Allergen Nomenclature Ory s 1	(1) Larsen & Lowenstein 2000
Isoallergens and Variants 2 gene family as indicated by DNA gel blot analysis (1)	(1) Xu et al. 1995
Molecular Mass 35 kDa (SDS-PAGE), 26 kDa (calculated) (1)	(1) Xu et al. 1995
Isoelectric Point	
Amino Acid Sequence, mRNA, and cDNA	
Protein Ory s 1	
SWISS-PROT: Q40638	
GenBank: U31771	
PIR: T03303	(1) Xu et al. 1995
Amino Acids 240	
mRNA precursor 1168 bp	
cDNA precursor	
cDNA Library / Recombinant Protein	
cDNA library: cDNA clones from mature rice anther, screened with Cyn d 1 specific Ab (1)	(1) Xu et al. 1995
Posttranslational Modifications	
Glycosylation: N-Glycosylation motif (N-X-(S/T) near N-terminus (1)	(1) Xu et al. 1995
Biological Function unknown	
Sequence Homology Lol p 1 from rye grass and Cyn d 1 from bermuda grass: aa sequence identity 66% and 63% (1)	(1) Xu et al. 1995
Localization Rice pollen: Ory s 1 gene is expressed in mature anthers, but not in vegetative or other floral tissues (1)	(1) Xu et al. 1995

6.3.2 Allergenic Properties

Major Pollen Allergen	References
Frequency of Sensitization IgE-binding to Ory s 1 from pooled serum of rye grass pollen allergic patients (1)	(1) Xu et al. 1995
Cross Sensitization IgE-binding to Ory s 1 observed by serum from grass pollen allergic patients from Melbourne (Australia), where no rice aeroallergens exist. Thus Ory s 1 is unlikely to be the primary sensitizing antigen in this case (1)	(1) Xu et al. 1995

<i>B-Cell Epitopes</i> IgE binding sites located on (the precursor sequence): aa 235-263 (C-terminal peptide) (1)	(1) Xu et al. 1995
<i>Recombinant Protein</i> Recombinant Ory s 1 completely abolished IgE- binding to native Ory s 1 (immunoblot inhibition) (1)	(1) Xu et al. 1995

7 Isolation & Preparation

Extract / Purified Allergens	Methods	References
Proteins	Defatted rice grain powder extraction with NaCl / NaHCO ₃ buffer (pH 8.0, containing phenol) at RT for 48h; centrifugation, dialysis, lyophilization, storage at 4°C	Urisu et al. 1991b
Albumin, globulin, prolamin and glutelin fractions	Subsequent extraction: water, salt, ethanol, acetic acid, salt/ethanol, alkali solutions; Extraction of rice powder for 4 h at RT, centrifugation, dialysis and lyophilization of supernatant, extraction of insoluble residues with similar procedure	Watanabe et al. 1990a
Globulin and glutelin fractions	Extraction of defatted rice flour with salt solution; a) supernatant: ammonium sulfate precipitation of globulin fraction; separation of 3 globulin fractions by SEC (Sephadex G-200) b) precipitate: washing and extraction of glutelin fraction with alkali solution	Shibasaki et al. 1979
Globulins (10 proteins)	Extraction of ground and defatted rice endosperm with 0.5M-NaCl, precipitation with trichloroacetic acid, fractionation with ammonium bicarbonate and ammonium bicarbonate / ethanol buffers, purification of total NaCl- and fractionated extracts by RP-HPLC	Limas et al. 1990
16 kDa allergen	Extraction of defatted rice grain powder with salt solution, ammonium sulfate precipitation of the supernatant, dialysis and lyophilization; IEC (DEAE cellulose) purification twice followed by SEC (Sephadex G-50)	Matsuda et al. 1988 Urisu et al. 1991b
14-16 kDa allergens	Sonication extraction of dehulled rice with salt solution, ammonium sulfate precipitation of the supernatant and dialysis; fractionation and purification of 5 proteins by IEC (DEAE cellulose) followed by RP-HPLC	Nakase et al. 1996

8 Cross-Reactivities

Cross-Reacting Allergens	Subjects / Methods	References
Rice Protein Fractions Glutelin and globulin fractions	1 rice allergic patient, allergenic potency: globulin > glutelin (RAST inhibition)	Shibasaki et al. 1979
Rice (Cereals, Pollen) a) cereals (wheat, corn, oats) b) rye grass pollen (group I)	Association of rice- and corn- specific IgE in 200 patients* (RAST) Differential cross- reactivities between all cereals (RAST inhibition)	Hoffman 1975
Rice (Cereals, Pollen) a) 5 cereals (wheat, rye, corn, oats)* b) grass pollen *	Correlation of skin reactivities between rice and a) corn 50%, rye 41%, wheat 38%, and oats 35% (SPT)* b) grass pollen (SPT)*	Lewis & Imber 1975
Rice (Cereals) 12 cereals (wheat, durum wheat, triticale, cereal rye, barley, rye grass, oats, canary grass, rice, maize, sorghum and Johnson grass)	4 asthmatic bakers (RAST, RAST inhibition)	Baldo et al. 1980
Rice Allergen (Cereals) 16 kDa rice allergen, 5 cereals (wheat, corn, Japanese and Italian millet)	6 rice allergic patients: Significant correlation of RAST values between protein extracts of all 5 cereals and between 16 kDa rice allergen and Italian millet *, Decrease of IgE-binding to all 5 cereals by 16 kDa rice allergen and vice versa (RAST, RAST inhibition)	Urisu et al. 1991b
Rice (Cereals, Legumes) wheat, soybean *	188 and 308 patients with atopic dermatitis: Close correlation between rice and wheat (0.78), and rice and soybean (0.65) (RAST)	Ikezawa et al. 1992b
Rice (Cereals) rice and maize (9 kDa lipid-transfer proteins, 16 kDa alpha-amylase/trypsin inhibitors)	Complete inhibition of IgE binding to 9 kDa and 16 kDa maize allergens by rice protein extract, as well as inhibition of 25-85 kDa minor maize allergens (immunoblot inhibition)	Pastorello et al. 2000
Rice (Seeds) buckwheat a) 23 buckwheat-sensitive subjects, b) 30 buckwheat-tolerant subjects with buckwheat and rice specific IgE	Significant correlation between rice and buckwheat specific RAST values in b), but not in a), Heterogenous (rice / buckwheat) RAST inhibition significantly lower than homologous (rice / rice, buckwheat / buckwheat) inhibition in a), no significant differences in b), Conclusion: common allergens from rice and buckwheat in a) and b), buckwheat specific allergens in a) (RAST, RAST inhibition)	Yamada et al. 1995
Rice (Cereals, Legumes) corn, soybean, and peanut	123 soybean, corn, rice, and peanut allergic patients: Significant RAST correlations between rice and corn (r=0.95) and rice and soybean (r=0.81), Significant inhibition of IgE- binding to rice by corn and peanut, and to corn and soybean by rice (RAST inhibition)	Lehrer et al. 1999
Rice (Pollen) Ory s 1, Lol p 1 from rye grass	Grass pollen allergic patients: Almost complete inhibition of IgE- binding to crude rice pollen extract by Ory s 1 and Lol p 1	Xu et al. 1995

* multiple sensitization (not proved by inhibition-tests)

9 Stability of Rice Allergens

Treatment	Effects	References
Rice Seeds, Rice Powder <i>(Hydrolysis)</i> enzymatic digestion with a) actinase and papain, b) actinase / surfactant (glycerin mono- oleate)	a) Rice seeds: reduction of RAST values to 22% (actinase) and 76% (papain) of non- treated rice Rice powder: reduction of RAST values to < 0.34 PRU/mL (actinase) and to 31% of non- treated rice (1 rice allergic patient) b) Rice seeds: reduction of RAST values to < 0.34 PRU/mL in 6 of 8 rice allergic patients	Watanabe et al. 1990a
Globulins <i>(Heat)</i> heat a) 60°C for 1 h, b) 100°C for 2 min, c) 100°C for 10 min	RAST activities of globulin fractions were reduced to 51-74% (RAST) Lymphocyte-stimulating activities of treatments a) and b) were enhanced up to 6 times of native activities	Shibasaki et al. 1979
Globulins <i>(Hydrolysis)</i> enzymatic digestion with actinase, papain, alpha-chymotrypsin, trypsin, pepsin, and pancreatin	RAST value for actinase treated rice < 0.34 PRU/mL, RAST activity reduced to > 50% by papain digestion, unchanged RAST for other enzymes (RAST, 1 rice allergic patient)	Watanabe et al. 1990a
Glutelins <i>(Heat)</i> heat a) 60°C for 1 h, b) 100°C for 2 min, c) 100°C for 10 min	RAST activities of glutelin fractions were reduced to 44-60% (RAST) Lymphocyte-stimulating activities of heated glutelins: no significant changes	Shibasaki et al. 1979

10 Allergen Sources

Reported Adverse Reactions	References
Food / Food additives Symptoms after ingestion of cooked rice (1)	(1) see Symptoms of Rice Allergy

Reported Safe Products	References
Food	see Hypoallergenic Rice
Pharmaceuticals Topical oat and rice colloidal grain suspensions used as adjuncts in bath therapies were evaluated for the treatment of atopic dermatitis: neither immediate urticarial nor allergic reactions occurred in any of 65 atopic or nonatopic children (Skin Patch Test), although 23% of atopic children were RAST positive (1)	(1) Pigatto et al. 1997

Associated Factors	References
Rice Burning Rice burn acreage was shown to have a small statistically significant effect on asthma morbidity in Butte County, USA (1)	(1) Jacobs et al. 1997

11 Hypoallergenic Rice

Products	Evaluation Methods	References
<i>Alkali Hydrolyzed Rice</i> Hypoallergenic rice (AFT-R 1) produced by alkali treatment, 15 rice allergic patients with severe atopic dermatitis	Reduction of major allergenic protein to less than 1/6400 (EAST) Clinical trial: Evaluated as useful in 93% of patients, Patient for whom AFT-R 1 was not useful: 60 kDa allergen detected in AFT-R 1 (SDS-PAGE immunoblotting)	Ikezawa et al. 1999
<i>Enzymatically Hydrolyzed Rice</i> Hypoallergenic rice produced by enzymatic digestion (actinase) in the presence of surfactant; the product, "Fine Rice" by commercial name, was approved as the first item of "food for specified health use" as defined by the Japan Ministry of Health and Welfare.	Hypoallergenic rice gave low specific Rast values and low atopic dermatitis area and severity index (ADASI) score. Generally resulting in satisfactory improvements in atopic dermatitis. Palatability and nutritive value are similar to non-treated rice.	Watanabe et al. 1990a, b Arai 1993 Watanabe 1993 Watanabe & Arai 1996
<i>Enzymatically Hydrolyzed Rice</i> Hypoallergenic rice (HRS-1) produced by enzymatic digestion (actinase and surfactant treatment), reduced content of salt- soluble globulin fraction, 44 patients with severe atopic dermatitis	Elimination of rice and wheat from daily diet, replacement with hypoallergenic rice (5.6 weeks on average): In 74% "moderate" to "remarkable" improvement, in 53% "moderate" to "remarkable" reduction in steroid ointment concomitantly used for the treatment (1, 2) Provocation test with regular rice in 5 of 44 subjects following the HRS-1 therapy: obvious increase in severity of symptoms in all 5 cases (2)	(1) Ikezawa et al. 1991 (2) Ikezawa et al. 1992a
<i>Hyperpressured Rice</i> Hypoallergenic rice: 95% of albumin and globulin were taken off by hyperpressure method	7 children with atopic dermatitis and rice specific RAST > 1: After introduction of hypoallergenic rice for 4 weeks skin reactions improved in all patients; Stimulation Index by rice albumin and globulin decreased to max. 22-97% (mean 71%) and 33-97% (mean 73%) (CAST)	Juji et al. 1999
<i>Hyperpressured Rice</i> Protein release from polished rice grains immersed in distilled water by high-pressure treatment (100-400 MPa) and additional treatment with proteolytic enzyme (protease-N from <i>Bacillus subtilis</i>) (incubation at 30°C, 18 h); after treatment rice grains were washed, rinsed, and freeze-dried	Major proteins which were released: 16 kDa albumin, alpha-globulin, and 33 kDa globulin; these proteins disappeared almost completely from rice grains by the pressurization in the presence of proteolytic enzyme (SDS-PAGE immunoblot)	Kato et al. 2000
<i>Transgenic Rice</i> Repression of 14-16 kDa allergen expression in rice seeds by antisense RNA strategy	Appr. 1/5 lower allergen content in transgenic cultivars as estimated using 16-kDa allergen specific mAb (ELISA, immunoblot)	Matsuda et al. 1996 Nakamura & Matsuda 1996 Tada et al. 1996

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Common Abbreviations

2D	two-dimensional
3D	three-dimensional
aa	amino acid(s)
Ab	antibody
Act c 1, 2	nomenclature of kiwi fruit allergens (<i>Actinidia chinensis</i>)
Api g 1-5	nomenclature of celery allergens (<i>Apium graveolens</i>)
Ara h 1-7	nomenclature of peanut allergens (<i>Arachis hypogaea</i>)
Bos d 4, 5, 6, 7, 8	nomenclature of cow's milk allergens (<i>Bos domesticus</i>)
C	concentration of N,N'-methylenebisacrylamide (crosslinker)
Cas s 1, 5	nomenclature of chestnut allergens (<i>Castanea sativa</i>)
CAST	cellular antigen stimulation test
CCD	cross-reactive carbohydrate determinants
CICBAA	Cercle d'Investigations Cliniques et Biologiques en Allergologie Alimentaire (France)
CIE	crossed immunoelectrophoresis
CNBr	cyanogen bromide
cIEF	capillary isoelectric focussing
CLA	cutaneous lymphocyte antigen
CLIE	crossed line immunoelectrophoresis
CMA	cow's milk allergy
CRIE	crossed radioimmunolectrophoresis
Cor a 1	nomenclature of hazel pollen allergens (<i>Corylus avellana</i>)
Cyn d 1	nomenclature of bermuda grass pollen allergens (<i>Cynodus dactylus</i>)
DBPCFC	double-blind, placebo-controlled food challenge
DEAE	diethylaminoethyl (cellulose) (anion exchanger)
DNA	deoxyribonucleic acid
DTT	dithiothreitol
EAST	enzyme allergosorbent test
EC	enzyme classification system
EDTA	ethylenediaminetetraacetic acid, disodium salt
ELISA	enzyme linked immunosorbent assay
EW	egg white
FEIA	fluorescence enzyme immunosorbent assay
Fuc	fucose
Gad c 1	nomenclature of baltic cod allergen (<i>Gadus callarias</i>)
Gal	galactose
Gal d 1-5	nomenclature of egg allergens (<i>Gallus domesticus</i>)
GlcN	glucosamine
GlcNAc	N-acetylglucosamine
Gly m 1, 2, 3	nomenclature of soybean allergens (<i>Glycine max</i>)
GST	glutathione-S-transferase
Hev b 1-10	nomenclature of latex allergens (<i>Hevea brasiliensis</i>)
HLA	human leucocyte antigen
Hol l 1	nomenclature of sweet velvet grass allergens (<i>Holcus lanatus</i>)

HPLC	high performance liquid chromatography
HPS	hydrophobic protein of soybean
HR	Histamine Release
IEC	ion exchange chromatography
IEF	isoelectric focussing
Ig	immunoglobulin
IL	interleukin
INF-gamma	interferon-gamma
Lol p 1	nomenclature of rye grass allergens (<i>Lolium perenne</i>)
LTA4	leukotriene A4
LTB4	leukotriene B4
LTC4	leukotriene C4
LTP	lipid transfer protein
LY	lysozyme
Man	mannose
Mal d 1, 2, 3	nomenclature of apple fruit allergens (<i>Malus domestica</i>)
MALDI-MS	matrix-assisted laser-induced desorption/ionization mass spectrometry
MAST	multiple allergen sorbent test
MHC	major histocompatibility complex
Mr	molecular mass
Mus a 1	nomenclature of banana allergens (<i>Musa spp.</i>)
NeuNAc	N-acetylneuraminic acid
NMR	nuclear magnetic resonance (spectroscopy)
NPV	negative predictive value
NRL	natural rubber latex
OA	ovalbumin
OAS	oral allergy syndrome
OM	ovomucoid
Ory s 1	nomenclature of rice allergens (<i>Oryza sativa</i>)
OT	ovotransferrin
PAGE	polyacrylamide gel electrophoresis
PBMC	peripheral blood mononuclear cells
PBS	phosphate buffered saline
Phl p 1	nomenclature of timothy grass allergens (<i>Phleum pratense</i>)
pI	isoelectric point
PCA	passive cutaneous anaphylaxis (test)
PCR	polymerase chain reaction
PPT	prick to prick test (skin test with fresh foods)
PPV	positive predictive value
Prs a 1 (Pers a 1)	nomenclature of avocado allergens (<i>Persea americana</i>)
Pru av 1, 2, 4	nomenclature of sweet cherry allergens (<i>Prunus avium</i>)
Pru p 3	nomenclature of peach allergens (<i>Prunus persica</i>)
PVDF	polyvinyliden difluoride
PVPP	polyvinyl polypyrrolidone
RAST	radioallergosorbent test

RBL cells	rat basophil leukaemia cells
RIEP	radioimmuno-electrophoresis
RNA	ribonucleic acid
RT	room temperature
SAFT	skin application food test
SDS	sodium dodecylsulfate
SEC	size exclusion chromatography
SPT	skin prick test
T	total acrylamide concentration
TCC	T-cell clone
TCL	T-cell line
TGF-beta-1	transforming growth factor beta-1
TH	thermolysin
TNF-alpha	tumor necrosis factor alpha
TR	trypsin
Tris	tris-(hydroxymethyl)aminomethane
WgA	wheat germ agglutinin
Xyl	xylose

Abbreviations of DNA-encoded Amino Acids

Alanine	Ala	A	Leucine	Leu	L
Arginine	Arg	R	Lysine	Lys	K
Asparagine	Asn	N	Methionine	Met	M
Aspartic acid	Asp	D	Phenylalanine	Phe	F
Cysteine	Cys	C	Proline	Pro	P
Glutamine	Gln	Q	Serine	Ser	S
Glutamic acid	Glu	E	Threonine	Thr	T
Glycine	Gly	G	Tryptophan	Trp	W
Histidine	His	H	Tyrosine	Tyr	Y
Isoleucine	Ile	I	Valine	Val	V