Rice-Induced Anaphylaxis: IgE-Mediated Allergy against a 56-kDa Glycoprotein

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Key Words

Anaphylaxis • Basophil activation test • Cross-reacting carbohydrate determinants • Food allergy • Immunoblot inhibition • *Oryza sativa* • Rice allergen

Abstract

Background: Although rice (*Oryza sativa*) is one of the most common cereals produced and consumed around the world, there have been only a few reports on immediate hypersensitivity reactions after ingestion of rice. Few clinical studies on rice allergy in Asia have been reported concerning rhinitis, asthma and atopic dermatitis. In this case study, we identify allergens presumably responsible for anaphylaxis after ingestion of rice in a German patient. **Methods:** Prick-to-prick tests, determination of specific IgE and the basophil activation test (BAT) were performed to confirm IgE-mediated allergy. IgE reactivity was further analyzed by immunoblotting of protein extracts from cooked commercial rice products. Rice allergens were purified, subjected to N-terminal sequencing and characterized by IgE binding and IgE inhibition assays using additional sera from 8 subjects with sensitization to rice and/or a history of hypersensitivity symptoms after rice ingestion. **Results:** Prick-to-prick tests

were positive to raw and cooked rice (basmati rice and long-grain rice) and preparations of different rice extracts. Specific IgE against rice (f9) was 1.87 kU_A/l. The BAT showed specific IgE-mediated activation of basophils after stimulation with rice extracts. Four IgE-reactive rice proteins with an apparent molecular weight of 49, 52, 56 and 98 kDa were identified. Interestingly, only binding to the 56-kDa glycoprotein was at least partially independent from cross-reactive carbohydrate determinants (CCD), whereas IgE binding to the other rice proteins was completely inhibited by pre-incubation with the CCD MUXF derived from bromelain. **Conclusions:** Yet unidentified high-molecular-weight allergens from rice seeds, predominantly a 56-kDa glycoprotein, seem to be responsible for anaphylaxis after consumption of rice in a German patient.

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Introduction

Rice is the seed of the monocot plant *Oryza sativa*. As a cereal grain, it is the predominant staple food especially in East and South Asia, the Middle East, Latin America and the West Indies. After maize, rice is the grain with

the second-highest worldwide production. Since maize crops are largely grown for purposes other than human consumption, rice is the most important grain with regard to human nutrition and provides 20% of the world's dietary energy supply, while wheat supplies 19% and maize 5% [1].

In contrast to its wide consumption, rice allergy seems to be exceedingly rare, and only few cases of IgE-mediated hypersensitivity are published. Most symptoms reported were rhinoconjunctivitis, bronchial asthma or generalized urticaria after inhalation of rice flour [2, 3] or steam of cooked rice [4, 5]. Other case reports were on contact urticaria after direct skin contact with raw rice [6–8]. Notably, there have been only few reports on immediate hypersensitivity reactions after ingestion of rice [2, 9–12] leading to rhinoconjunctivitis [11, 12], bronchial asthma [9–11] and acute gastrointestinal symptoms [2]. A study in Japan suggested a correlation between rice allergy and aggravation of atopic eczema after rice ingestion [13].

So far, only 2 allergens from rice pollen, Ory s 1 (β -expansin) [14] and Ory s 12 (profilin A), are included in the official allergen database of the International Union of Immunological Societies Allergen Nomenclature Subcommittee [15]. The major rice pollen allergen Ory s 1 (35 kDa) covers 66% sequence identity to the rye grass pollen allergen Lol p 1 [14]. Moreover, Ory s 2, Ory s 7 (calcium-binding protein, polcalcin), Ory s 11 (trypsin inhibitor, TI), Ory s 13 (polygalacturonase) and Ory s 23 were described as putative allergens from rice pollen [16]. Ory s aA/TI, a 14- to 16-kDa α -amylase/TI [17, 18] and a 33-kDa Ory s glyoxalase I [19] were described as potential food allergens from rice seed. Recently, it was shown that a lipid transfer protein (LTP) from rice seeds, Ory s 14, was the relevant allergen of rice-induced anaphylaxis in 3 patients, whereby the rice LTP cross-reacted with peach/apple LTP [20].

Here, we report results of in vivo and in vitro diagnostic procedures in a German patient who had repeated anaphylaxis episodes after consumption of rice. We identified 4 glycosylated IgE-binding proteins in rice seed, including the likely relevant allergen of 56 kDa.

Materials and Methods

Rice-Allergic Patient and Patient Sera

Within 3 years, a 33-year-old German male had several episodes of generalized urticaria, pruritus, angioedema of the lips, eyelids and tongue, dysphagia and dyspnea 15–20 min after eating whole meals containing cooked rice. No previous food allergy,

including oral allergy syndrome, or drug hypersensitivity was known. He has a grass/rye pollen allergy with only mild seasonal symptoms. His family is not of Asian descent. After completion of the in vitro and in vivo investigations, our patient was advised to avoid all kind of cooked rice food. He can eat noodles, potatoes, maize, bread and any kind of other cereal without symptoms. Moreover, additional sera from 8 German subjects reporting hypersensitivity symptoms upon ingestion of cooked rice and/or with sensitization to rice were included in the study to analyze IgE-reactive proteins.

Skin Tests

Skin prick tests (SPTs) were performed with commercially available allergens (pollen from grass, rye, birch, alder, hazel, beech, mugwort, cat and dog danders, house dust mites, egg, milk, herring and hazel nut; ALK-Scherax, Hamburg, Germany) and standardized food prick-to-prick test with celeriac, carrot, tomato, apple, orange, banana, fish, milk, egg yolk, egg white, rye flour, wheat flour, soya flour, guar flour, hazel, peanut, walnut, almond, mustard seed, pepper, red pepper, curry, oat, buckwheat, millet and maize. Rice seeds from basmati rice and long-grain rice were tested raw as ground powder and after cooking for 20 min. In addition, prepared extracts from basmati rice and long-grain rice, and a commercially available basmati rice extract (Squarix, Marl, Germany) were used for SPTs in concentrations of 10 and 100 μ g/ml. A positive prick test reaction was defined as '1+' with a wheal diameter of 3–4 mm, as '2+' with a wheal diameter of 4–6 mm and as '3+' with a wheal diameter >6 mm. All tests were performed according to the recommendations of the European Academy of Allergy and Clinical Immunology [21].

Determination of Specific IgE to Rice and Potentially Cross-Reacting Cereals

Sera were analyzed for specific IgE antibodies to rice (f9) and glycopeptide MUXF (Ro214) by the Pharmacia ImmunoCAP® System (Pharmacia Diagnostics, Uppsala, Sweden), according to the instructions of the manufacturer. Serum of the rice-allergic patient was further tested for specific IgE to rye flour (f5), wheat flour (f4) and oat flour (f7).

Rice Extracts

Protein extracts were prepared from cooked (20 min, 100°C) basmati rice and long-grain rice. Upon heating, samples were frozen in liquid nitrogen and homogenized. Proteins from 5 g of frozen material were extracted in PBS buffer (12 ml). Supernatant was filtered and subjected to SpeedVac centrifugation to enhance protein concentration to 40 (basmati rice extract) and 60 μ g/ml (long-grain rice extract), respectively. In addition, a commercially available extract (2.3 mg/ml PBS, 100 mM sodium chloride, pH 7.4) prepared without heating from crude basmati rice was used (F-1312; Squarix).

Basophil Activation Test

Blood (5 ml) from the rice-allergic patient and a non-allergic control was used within 6 h of blood sampling for the basophil activation test (BAT). The BAT is a flow-cytometric cellular allergen stimulation test which is based on the in vitro allergen-induced specific activation of basophils [22]. The assay was performed using a Flow-CAST® kit according to the instructions of the manufacturer (Bühlmann Laboratories, Basel, Switzerland).

Briefly, leukocytes were stimulated with rice extracts (Squarix and long-grain rice) at concentrations ranging from 0.1 to 10^{-5} $\mu\text{g/ml}$, a control antigen (extract from lettuce and endive), and a negative (buffer) and positive control (activating anti-Fc ϵ RI antibody). The cells were double stained with anti-CD63-PE- and anti-IgE-FITC-labeled antibodies. Activated basophils (CD63+ and IgE+, double-positive cells) were counted flow-cytometrically at 488 nm on a FACS Calibur (Becton Dickinson Immunocytometry Systems, Mansfield, Mass., USA) using CellQuest Software.

SDS-PAGE and IgE Immunoblotting

Protein extracts from cooked long-grain rice, basmati rice and a commercial basmati rice extract (Squarix) were separated under non-reducing conditions by SDS-PAGE (5 μg protein/cm slot) in a 15% separation gel using a BioRad (Munich, Germany) Mini-Protean cell and subjected to silver staining. In addition, proteins were transferred onto nitrocellulose (0.2 μm , 45 min, 150 V), membranes were blocked with skimmed milk (5% in TBS, supplemented with 0.05% Tween) and used for IgE immunoblotting. To detect allergen-specific IgE antibodies, sera from the rice-allergic patient and a non-allergic control were diluted 1:10 in TBST and incubated with the blot strips overnight. After washing, bound IgE antibodies were detected with alkaline-phosphatase-conjugated monoclonal mouse anti-human IgE (1:750; PharMingen, San Diego, Calif., USA). Visualization was performed by NBT/BCIP substrate (BioRad). Furthermore, adjusted amounts of purified rice proteins were loaded onto SDS-PAGE (12.5%, non-reducing conditions). Screening of IgE reactivity of sera ($n = 9$) was performed with an anti-human IgE antibody conjugated with biotin (1:750), streptavidin conjugated with alkaline phosphatase (1:3,000) and NBT/BCIP as substrate (BioRad).

Purification of Rice Allergens

Protein extract (7.5 ml, 2.3 mg/ml) from basmati rice (Squarix) was subjected to preparative SDS-PAGE (T: 11%) under non-reducing conditions using PrepCell (BioRad). Fractions ($n = 175$; 2.7 ml each) were analyzed by SDS-PAGE and Coomassie blue staining. Subsequently fractions displaying purified proteins with an apparent molecular weight of 49 kDa (fractions 61–67), 52 kDa (fractions 72–77), 56 kDa (fractions 83–90) and 98 kDa (fractions 170–175) were pooled. Purified proteins were subjected to IgE immunoblotting and IgE inhibition assays, and transferred to PVDF membranes for N-terminal sequencing.

IgE Inhibition Assay

Sera of rice-allergic patients (1:10) were pre-incubated with 100 μg glycopeptide MUXF derived from bromelain or 100 μg glycopeptide MM, and subsequently analyzed for cross-reactivity with purified rice allergens blotted onto nitrocellulose. N-linked glycopeptides with the glycan structure $\text{Man}\alpha 1-6(\text{Xyl}\beta 1-2)\text{Man}\beta 1-4\text{GlcNAc}\beta 1-4(\text{Fuc}\alpha 1-3)\text{GlcNAc}$ (MUXF) coupled to 2–4 amino acids were prepared from pineapple stem bromelain by digestion with pronase followed by a series of chromatographic steps, as described elsewhere [23]. Glycopeptides containing the pentasaccharide core $\text{Man}\alpha 1-6(\text{Man}\alpha 1-3)\text{Man}\beta 1-4\text{GlcNAc}\beta 1-4\text{GlcNAc}$ (MM) were prepared from bovine fibrin. Immunodetection was performed as described above.

Results

SPTs and Specific IgE

SPTs using commercially available allergens were positive to pollen of grass, rye, birch, alder, hazel and to house dust mites. Standardized food prick-to-prick tests revealed positive reactions to walnut, almond and mustard seed. SPT with raw and cooked rice seeds (basmati rice and long-grain rice) and with rice extracts at 100 $\mu\text{g/ml}$, prepared from basmati rice, long-grain rice and the commercially available extract from basmati rice (Squarix), revealed positive reactions, respectively (table 1). SPTs with other cereals, including rye, wheat, oat, buckwheat, millet and maize, were negative. Specific IgE to rice (f9) was 1.87 $\text{kU}_\text{A}/\text{l}$, to rye flour (f5) 3.18 $\text{kU}_\text{A}/\text{l}$, to wheat flour (f4) 2.80 $\text{kU}_\text{A}/\text{l}$ and to oat flour (f7) 2.10 $\text{kU}_\text{A}/\text{l}$. Specific IgE to codfish (f3) and herring (f205) were <0.35 $\text{kU}_\text{A}/\text{l}$ (negative). Total IgE was 136 $\text{kU}_\text{A}/\text{l}$.

Basophil Activation Test

Activation of the patient's basophils after stimulation with different concentrations of basmati rice extract (Squarix) yielded up to 61% activated basophils at low allergen concentrations of 10^{-5} $\mu\text{g/ml}$, compared to 14% background of the negative control (fig. 1). Activation of basophils was also induced by long-grain rice extract up to 35% at concentrations of 10^{-2} $\mu\text{g/ml}$ (data not shown). In contrast, basophil activation was negative in the control person upon stimulation with all rice extract concentrations, i.e. 4.5 and 1% activated basophils at 0.1 and 10^{-5} $\mu\text{g/ml}$ basmati rice extract, respectively (fig. 1). Stimulation with a clinically non-relevant control antigen (extract from lettuce and endive) was negative (8.6 and 4.6%, respectively) in both, the patient and the control (data not shown). Positive controls by activating anti-Fc ϵ RI antibody yielded basophil activation of 60 and 41% in both, the patient and the non-atopic control (fig. 1).

Patient Sera Show IgE Reactivity to

High-Molecular-Weight Proteins in Rice Extracts

All 3 self-prepared extracts prepared from cooked rice displayed a similar protein pattern, whereas the Squarix extract showed a more distinct protein pattern with some additional prominent bands in the low-molecular-weight range (fig. 2a). IgE immunoblotting using the serum from the rice-allergic patient revealed a single strong band with an apparent molecular weight of approximately 56 kDa for 3 self-prepared rice extracts and IgE-binding reactivity to proteins in a range of 50–98 kDa for the Squarix extract (fig. 2b). To further characterize the IgE-

Table 1. Clinical features of the patient and results of prick-to-prick skin tests with different rice preparations

Patient characteristics	
Sex/age	Male/33 years
Nationality/race	German/Caucasian
Occupation	Pizza baker
History of allergy	Grass/rye pollen allergy (starting 11 years ago) No food allergy, no oral allergy syndrome
Onset of rice allergy	Age: 32 years/4 episodes within 6 months
Duration/threshold	Anaphylaxis within 20 min after eating a rice dish; symptoms until emergency treatment
Offending rice dish	Indian chicken with basmati rice, goulash (beef, paprika) and rice, risotto with chicken and saffron
Symptoms	Urticaria, pruritus, angioedema, dyspnea
IgE	Rice-specific IgE 1.87 kU _A /l/total IgE 136 kU _A /l
SPT with commercial allergens	Positive: grass, rye, birch, alder and hazel pollen, house dust mites Negative: beech, mugwort, cat/dog danders, egg, milk, herring, hazel nut
Food prick-to-prick tests	Positive: walnut, almond, mustard seed Negative: celeriac, carrot, tomato, apple, orange, banana, fish, milk, egg yolk, egg white, rye flour, wheat flour, soya flour, guar flour, hazel, peanut, pepper, red pepper, curry, oat, buckwheat, millet, maize
Prick-to-prick skin tests with rice seed preparations	
Test reaction	
Basmati rice (raw)	1+
Basmati rice (cooked)	2+
Long-grain rice (raw)	1+
Long-grain rice (cooked)	3+
Basmati rice extract 10 µg/ml	–
Basmati rice extract 100 µg/ml	1+
Long-grain extract 10 µg/ml	–
Long-grain extract 100 µg/ml	2+
Basmati rice extract (Squarix) 10 µg/ml	–
Basmati rice extract (Squarix) 100 µg/ml	2+
Negative control	–
Histamine-positive control	3+
Positive test reactions were defined as described in Materials and Methods.	

binding profile of high-molecular-weight proteins from the Squarix extract, proteins were separated by preparative SDS-PAGE. Four pooled fractions displayed pure proteins of approximately 49, 52, 56 and 98 kDa (not shown). All 4 proteins were detected by IgE from our rice-allergic patient (fig. 2c–f; lane 9).

Using additional sera ($n = 8$; fig. 2c–f; lanes 1–8) from subjects reporting hypersensitivity symptoms upon rice ingestion and/or with an IgE immune response to rice, 3 of 8 sera recognized all 4 purified rice proteins tested (fig. 2c–f; lanes 2, 4, 5). These 3 sera showed also positive ImmunoCAP results with rice extract (8.59, 3.41 and 1.6

kU_A/l). All 5 patients without IgE binding to the investigated rice proteins (fig. 2c–f; lanes 1, 3 and 6–8) reported rice-induced hypersensitivity symptoms. Only for 1 patient (No. 1), IgE immune response to rice and cross-reactive carbohydrate determinant (CCD) was confirmed by ImmunoCAP testing.

Characterization of Rice Allergens

Purified rice allergens were subjected to N-terminal sequencing. But since all proteins were N-terminally blocked, no amino acid sequence information could be obtained. To further characterize the nature of the rice

Fig. 1. BAT: blood cells stimulated in vitro with allergens (rice extract/control antigens) were double stained with anti-IgE and anti-CD63 monoclonal antibodies (mAb) and analyzed by flow cytometry. Histograms show gated IgE-positive cells analyzed for the activation marker CD63. Basophil activation after stimulation with basmati rice extract (Squarix) was positive in the patient (61%) and negative in the control person (1%).

allergens, IgE inhibition studies with glycopeptide MUXF derived from bromelain were performed. IgE reactivity to the 49-, 52- and 98-kDa proteins was completely inhibited by pre-incubation of the serum from the rice-allergic patient with MUXF (fig. 3a, b, d; lane 2). In contrast, IgE binding to the 56-kDa allergen was only partially inhibited by MUXF (fig. 3c; lane 2). This CCD inhibition pattern was confirmed using serum from patient No. 4, sensitized to all 4 purified rice proteins (fig. 2c–f; lane 4). Pre-incubation of sera with glycopeptide MM used as negative control did not compete IgE binding to the rice proteins (fig. 3a–d; lane 3). In conclusion, inhibition assays indicate that cross-reactive carbohydrates significantly contributed to the IgE binding of different rice proteins.

Discussion

So far, rice has been described merely as inhalant [2–5] or contact allergen [6–8], rather than as food allergen [2, 9–12, 20]. In Europe and North America, food allergy due

to rice causing IgE-mediated anaphylaxis has been reported very rarely [2, 10, 12, 20]. Symptoms after rice ingestion have involved the skin (urticaria) [2, 5–7, 20], the respiratory tract (rhinoconjunctivitis or bronchial asthma) [4, 10, 12] and the gastrointestinal system [2]. In some cases, rice might also account for specific food-dependent exercise-induced anaphylaxis [24]. The development of food allergy is influenced by genetic factors, cultural and dietary habits, and exposure to allergens early in life. Rice is the main daily food particularly in Eastern Asia. Accordingly, rice food allergy is reported more commonly in Asian countries, e.g. the prevalence of rice food allergy in Japanese atopic subjects was estimated to be as high as 10% [13].

In the present study, we report on a German patient who exhibited several episodes of anaphylaxis after ingestion of cooked rice. Symptoms occurred within 20 min and comprised generalized urticaria, pruritus, angioedema, dysphagia and bronchospasm. Because of unequivocal history, anaphylaxis symptoms, IgE reactivity confirmed by skin tests with different rice extracts with raw and cooked rice, and by two different in vitro test

Fig. 2. a–f Protein extracts from heated (20 min, 100°C) long-grain rice (two manufacturers: lanes 1 and 3) and Basmati rice (lane 2), and a commercial rice extract (Squarix; lane 4) were separated by SDS-PAGE under non-reducing conditions and subjected to silver staining (a) and IgE immunoblotting (b). IgE binding was analyzed using buffer (lane a) and serum from the rice-allergic patient (1:10 dilution; lanes b and c) each with the 4 extracts. Alkaline-phosphatase-labeled anti-human IgE (1:750) was used

as secondary antibody (b). IgE-reactive high-molecular-weight proteins from commercial basmati rice extract (Squarix) were purified by preparative SDS-PAGE and investigated for IgE reactivity to proteins of 49 (c), 52 (d), 56 (e) and 98 kDa (f) each with sera derived from patients reporting hypersensitivity symptoms after ingestion of rice (No. 1–8), serum from our rice-allergic patient (no. 9) and a negative control (NC).

methods, i.e. BAT and specific serum IgE, we decided against food challenge testing. After consequently eliminating rice from his diet, no further food-associated symptoms occurred. Our patient demonstrated a positive SPT response to rye grass pollen, corresponding to mild seasonal rhinitis, whereas SPTs with cereal seeds such as rye, wheat, oat, buckwheat, millet and maize were negative. Although cereal grains may show cross-reactivity with rye grass pollen [14] and with each other [25], our patient had no symptoms after eating these cereals.

A variety of allergens from rice pollen and rice seeds have been described (summarized in table 2). Rice seed proteins with molecular weights of about 14–16, 19, 25, 26–28, 33, 50, 53, 56, 60 and 90 kDa were previously shown to be reactive with IgE antibodies from patients with suspected rice allergy (references are cited in table 2). A multigene family of 14- to 16-kDa proteins represents the major allergens from rice seeds that were characterized as α -amylase/TI with significant homology to wheat and barley, being responsible for occupational asthma in bakers [17, 18]. The 26-kDa allergen represents a major seed storage protein, α -globulin. Other rice seed allergens identified are a 33-kDa protein with glyoxalase I activity [19] and a 60-kDa protein [11]. Furthermore, cross-reactivity of rice proteins to an LTP from maize has been demonstrated, indicating the presence of this plant pan allergen in rice [26].

To evaluate the allergenic potency of rice proteins in our patient, BAT was performed using 2 diluted rice extracts. Activation of basophils was still induced at very low concentrations of rice extract (10^{-5} μ g/ml), indicating rather high allergenic potency. Furthermore, we investigated IgE binding to rice protein extracts from 2 cooked rice varieties and 1 native basmati rice extract (Squarix; prepared without cooking). Noteworthy, in all extracts the patient's serum constantly detected a 56-kDa band. For further characterization, this 56-kDa protein and 3 additional IgE-reactive proteins of approximately 49, 52 and 98 kDa have been purified and shown to be recognized by the serum from our rice-allergic patient as well as by 3 additional sera from patients who reported hypersensitivity symptoms after rice ingestion. IgE inhibition assays showed that all 4 purified putative allergenic proteins, i.e. 49, 52, 56 and 98 kDa, express IgE-reactive glycan structures, indicating that CCD contributed to IgE binding. Interestingly, only IgE reactivity to the 56-kDa protein was not completely inhibited by pre-incubation with the MUXF-glycopeptide. Therefore, the heat-stable 56-kDa protein may be the allergen responsible for the anaphylactic reactions after consumption of rice in

Fig. 3. a–d. Determination of IgE cross-reactive glycan structures. Serum from the rice-allergic patient (No. 9) was preincubated with MUXF-(lane 2) or MM-glycopeptides (lane 3) and buffer (lane 1) as controls, and subsequently incubated with blotted purified rice allergens of 49 (a), 52 (b), 56 (c) and 98 kDa (d).

our patient. One can speculate that the IgE epitopes of the 56-kDa protein are determined by both the heat-stable CCD and the protein structure. Unfortunately, the structure of this glycosylated 56-kDa allergen has not been elucidated yet.

In summary, we identified 4 glycosylated proteins as potential food allergens in rice seed. Results of inhibition studies indicate that the 56-kDa glycoprotein may be the allergen responsible for the anaphylaxis after rice consumption in our patient.

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Table 2. Seed and pollen allergens of rice

Molecular weight	Description	Allergen nomenclature	Associated symptoms	References
Rice seed allergens				
14 kDa	LTP	Ory s 14	generalized urticaria and/or angioedema after rice ingestion	20
14–16 kDa	α -amylase/TI	Ory s aA/TI	generalized urticaria by inhalation of rice steam [5], rice food allergy in asthma patients [11]	5, 11, 17, 18, 25, 27
16 kDa	major allergen	–	atopic dermatitis	25, 28
19 kDa	–	–	rhinoconjunctivitis after rice ingestion [12]	12, 25
25, 26–28 kDa	major allergen, α -globulin	–	urticaria by inhalation of rice steam [5]; asthma	5, 25, 27, 28
33 kDa	Glb33, glyoxalase I activity protein	Ory s glyoxalase I	rhinoconjunctivitis, asthma by inhalation of rice vapours [4]; rice food allergy in asthma patients [11]	4, 11, 19
53, 56, 60 kDa	–	–	rice food allergy in asthma patients	11
50, 90 kDa	major allergen	–	atopic dermatitis	28
49, 52, 56, 98 kDa	glycoproteins	–	generalized urticaria, angioedema, dysphagia and bronchospasm	present study
Rice pollen allergens				
35 kDa	major pollen allergen (group I; β -expansin)	Ory s 1 ¹	asthma, allergic rhinitis and allergic conjunctivitis after exposure to rice pollen	14–16
14 kDa	profilin A	Ory s 12 ¹	–	15, 16
12–13 kDa	pollen allergen (group II/III)	Ory s 2	–	16
16, 26, 32 kDa	–	–	asthma in children	29
–	polcalcin TI polygalacturonase –	Ory s 7 Ory s 11 Ory s 13 Ory s 23	–	16
¹ Denominated by the IUIS Allergen Nomenclature Sub-Committee [15].				

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