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Kiwi fruit allergy: A new birch pollen–associated food allergy

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Sections

- [Abstract](#)
- [Methods](#)
- [Results](#)
- [Discussion](#)
- [References](#)
- [Publishing and Reprint Information](#)
- [Articles with References to this Article](#)

Abstract

Background: To determine the cross-reacting antigens of kiwi fruit and other foods and pollen, we investigated 22 patients allergic to kiwi fruit: 10 with severe systemic reactions and 12 with localized symptoms confined to oral and pharyngeal mucosa (oral allergy syndrome). Seven patients with birch pollen allergy who tolerated kiwi fruit were included as a control group.

Methods: All patients were evaluated by skin testing and RAST; three patients were evaluated by RAST inhibition assays.

Results: Prick tests showed positive reactions to kiwi fruit in all patients, whereas specific IgE to kiwi fruit could be demonstrated only in patients with generalized severe symptoms. Surprisingly, all 22 patients with clinical kiwi allergy showed positive prick test results and elevated IgE to birch pollen. Clinically, all complained of rhinitis during birch pollen season. Many patients showed sensitization to grass and mugwort pollen. Also, food allergy was found to be associated with kiwi allergy: we found strong reactions to apple and hazelnut; moderate reactions to carrot, potato, and avocado; and weak reactions to wheat and rye flour, pineapple and papaya, and their enzymes bromelain and papain. RAST inhibition studies revealed cross-reacting antigens between birch pollen and kiwi fruit. Interestingly, patients with birch pollen allergy without clinical signs of kiwi allergy had positive prick test reactions to kiwi. Patients with kiwi allergy showed higher concentrations to birch pollen IgE compared with patients with isolated birch pollen allergy.

Conclusions: Our results indicate that kiwi allergy is a new manifestation of birch pollen–associated food allergy and is mediated by cross-reacting antigens in the kiwi fruit. Kiwi allergy can be expected in patients with birch pollen allergy exhibiting high levels of IgE to birch pollen. (J ALLERGY CLIN IMMUNOL 1994;94:70-6.)

Abbreviation used

PBS Phosphate-buffered saline

Key words: [Kiwi fruit allergy](#), [cross-reactivity](#), [birch pollen allergy](#), [food allergy](#)

Immediate-type hypersensitivity reactions after the ingestion of kiwi fruit have been published with greater frequency during the past 10 years.¹⁻⁵ The clinical symptoms range from localized symptoms confined to the oral mucosa to severe anaphylactic reactions. Interestingly, in several patients kiwi fruit allergy was associated with food and pollen allergy.⁶⁻⁹ Recently, we provided preliminary evidence for cross-reacting antigens in kiwi fruit and birch pollen.¹⁰ The findings prompted us to study a group of 22 patients with kiwi allergy for associated allergies by means of skin testing, determination of specific IgE, and RAST inhibition assays. We can demonstrate that most patients with kiwi allergy have positive prick test reactions and elevated levels of specific IgE to birch pollen; also, patients with birch pollen allergy without clinical kiwi allergy have positive prick test reactions to fresh kiwi fruit. Thus kiwi allergy represents a new manifestation of birch pollen-associated food allergy.

Methods

Patients

During 1989 and 1990, 22 patients, aged 17 to 33 years (mean age, 22.0 years), with a history of allergic reactions to kiwi fruit were referred to the Department of Dermatology, University of Ulm. (Ten patients had severe generalized symptoms such as angioedema, pharyngeal swelling, and dyspnea; 12 patients had oropharyngeal pruritus.) Because virtually all of the patients with kiwi allergy also had birch pollen allergy, seven patients, aged 20 to 26 years (mean age, 22.7 years), with isolated birch pollen allergy and moderate symptoms during the birch pollen season were included in this study as a control group.

Allergy test procedure

Prick testing

In all patients, fruits and vegetables were tested in native form by means of a modified skin prick technique: fresh substances were placed on the forearm and penetrated by a prick test needle. Skin tests with fresh fruits and vegetables were done in a similar way in 10 nonatopic and nonallergic subjects, aged 23 to 39 years (mean age, 32.9 years), ruling out nonspecific reactions caused by histamine releasing factors or pharmacologically active substances in the fresh foods. Because all skin test results in the 10 control subjects were negative, the positive skin test results in the patients with a history of adverse reactions to kiwi fruit are considered specific allergic reactions. The pollen and flours were tested with test substances from Bencard Company (Worthing, U.K.). For practical reasons, perennial allergens were not tested in this series.

Thermolability of kiwi allergens

To test the thermolability of kiwi allergens, kiwi fruits were heated from 40° C to 90° C, in a microwave oven with the use of a temperature sensor. Heated kiwi fruits were tested in three patients as described above.

RAST and RAST inhibition assays

To produce allergen disks, fresh fruits with 20% weight of fruit (wt/vol) were sliced and extracted with phosphate-buffered saline (PBS) solution (pH = 7.4) consisting of 2 mmol/L ethylenediaminetetraacetic acid, 2 mmol/L polyvinylpyrrolidone, and 3 mmol/L sodium azide (NaN₃).¹¹ The enzymes bromelain and papain were purchased from Sigma Chemie (Deisenhofen, Germany), and disks were prepared with concentrations of 10 mg/ml. Prick test solutions for pollen and flours 2.5% (wt/vol) were obtained from Bencard Company and coupled to the disk diluted 1:1 with PBS.

Preparation of allergen disks

The activation of cellulose disks (Schleicher and Schüll, Dassel, Germany) with bromcyanide and the covalent binding of the respective allergens was done according to the method of Ceska et al.¹² One thousand milliliters of bromcyanide solution (2.5% in water) was added to 20,000 disks and mixed with a mechanical stirrer for 10 minutes in a water bath at room temperature. Sodium hydroxide (1 mol/L) was added by drops to maintain the pH range of 10.0 to 10.5. The paper disks then were washed three times with distilled water and three times with acetone (per analysis) and placed on a filter paper in the cold room (4° C) for 3 hours. The drying was continued overnight in a vacuum desiccator. The dried paper disks were then stored at –20° C and used for coupling of allergens. The chemical binding of 100 activated disks was done with 20 ml of solution of allergens in PBS buffer. The required allergen solutions had a concentration that yielded a protein binding of the disks at a minimum of 1 µg/ml.

RAST assays

Allergen-specific IgE antibody levels were measured with the conventional Phadebas RAST (Pharmacia Diagnostics AB, Uppsala, Sweden). For calibration of the allergen disks, we produced at the same time for each charge of activated disks birch pollen disks. These birch pollen disks underlaid quality controls with positive and negative sera classified by Pharmacia RAST. The deviation of RAST results with these disks and sera (referring to counts per minute) was less than 5%. Additionally, disks with “new” allergens were checked with negative control sera obtained from nonatopic and nonallergic persons. Disks were only used for rating RAST classes 0 to IV (according to the Pharmacia RAST system), when the negative control sera resulted in counts per minute clearly less than RAST class I.

The assay was performed according to the manufacturer's instructions.¹³ Briefly, 50 µl of undiluted serum was incubated with appropriate allergen disk(s) for 3 hours at room temperature. After washing the disks three times with 0.9% saline solution, 50 µl of anti-IgE iodine 125* (0.5 µg, ≈6 µCi) was added. The reaction mixture was incubated overnight (16 to 24 hours) at room temperature, and the disks were again washed three times with 0.9% saline solution. The amount of bound radioactivity was determined with a gamma counter, counting for 2 minutes. Phadebas RAST reference sera A to D were tested in a similar manner in duplicate in all assay runs. The specific IgE was expressed as percentage of the total anti-IgE that could be detected on the respective allergen disk. Binding of 2.5% or more indicated a positive RAST result. Scoring and evaluation was done by comparing count rates of the patients' sample with count rates of the reference sera (D = 1.5% to 4%, C = 2.5% to 6%, B = 8% to 20%, A = > 20%). The response of the patients' sample can also be classified in Phadebas RAST classes, 0 to IV, as follows: < reference D = class 0, reference D = class I, reference C = class II, reference B = class III, and reference A = class IV.

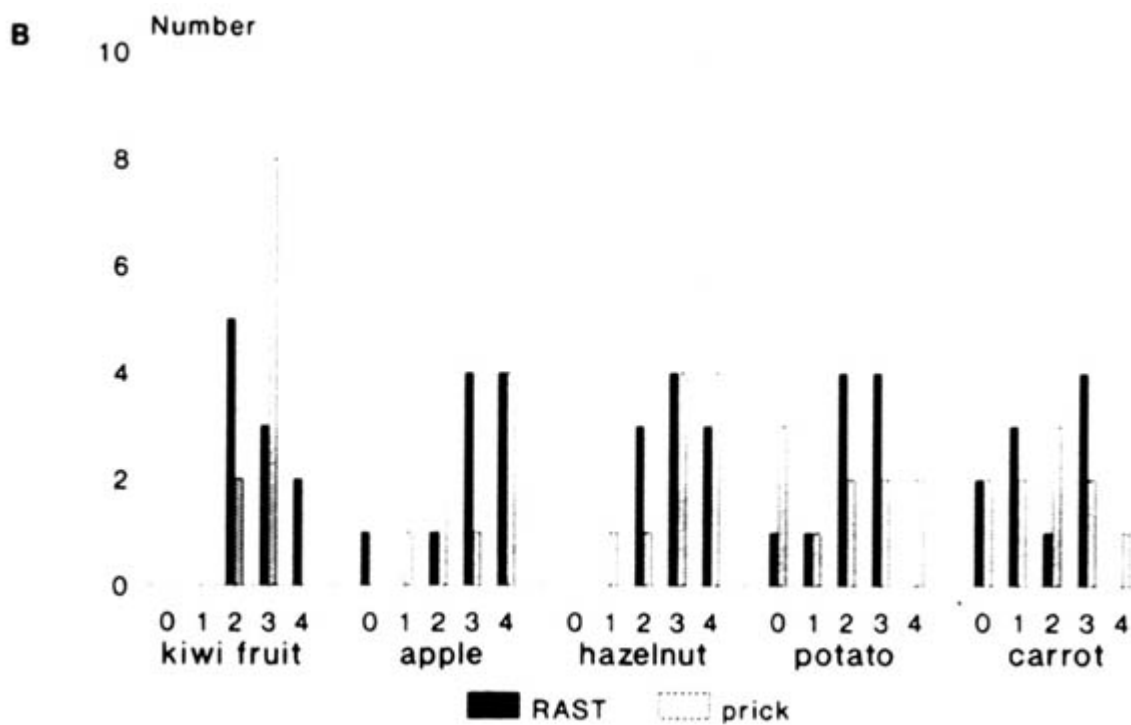
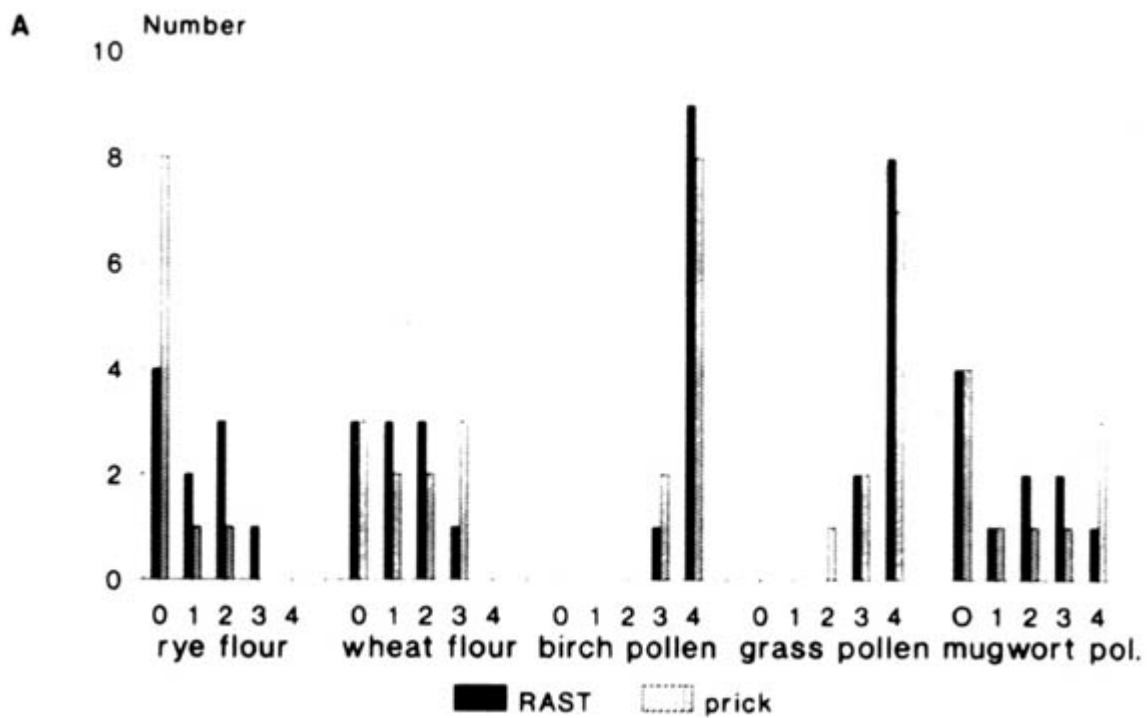
The RAST inhibition assays for detection of cross-reacting antigens were carried out according to the method of Kalveram and Forck.¹⁴ A given allergen is added to the test serum, and the decrease in measured specific IgE is interpreted to result from absorption of IgE to the allergen incubated. Allergen extracts, as mentioned above, were added in defined dilution steps to the serum to be tested. The dilution still resulting in at least 50% reduction of the specific IgE value is given. RAST inhibition assays were performed in three cases in which patients had high IgE levels to kiwi fruit (patients 2, 6, and 10).

Results

Skin tests

Surprisingly, all 22 patients who had been included in this study because of their kiwi allergy showed positive prick test reactions to birch pollen; sensitization to other pollens was found in the majority of cases. The strongest sensitizations occurred in response to birch pollen and grass pollen, whereas weaker reactions occurred in response to mugwort (■Fig. 1, A and ■Fig. 2, A).

FIG. 1. Group 1: IgE values and skin test results in 10 patients with severe clinical symptoms after kiwi fruit ingestion. Scale of the IgE values: 0 = negative; the numbers 1 to 4 correspond to the RAST classes I to IV. Assessment of the skin test results: 0 = negative, 1 = +, 2 = ++, 3 = + + +, and 4 = + + + +.



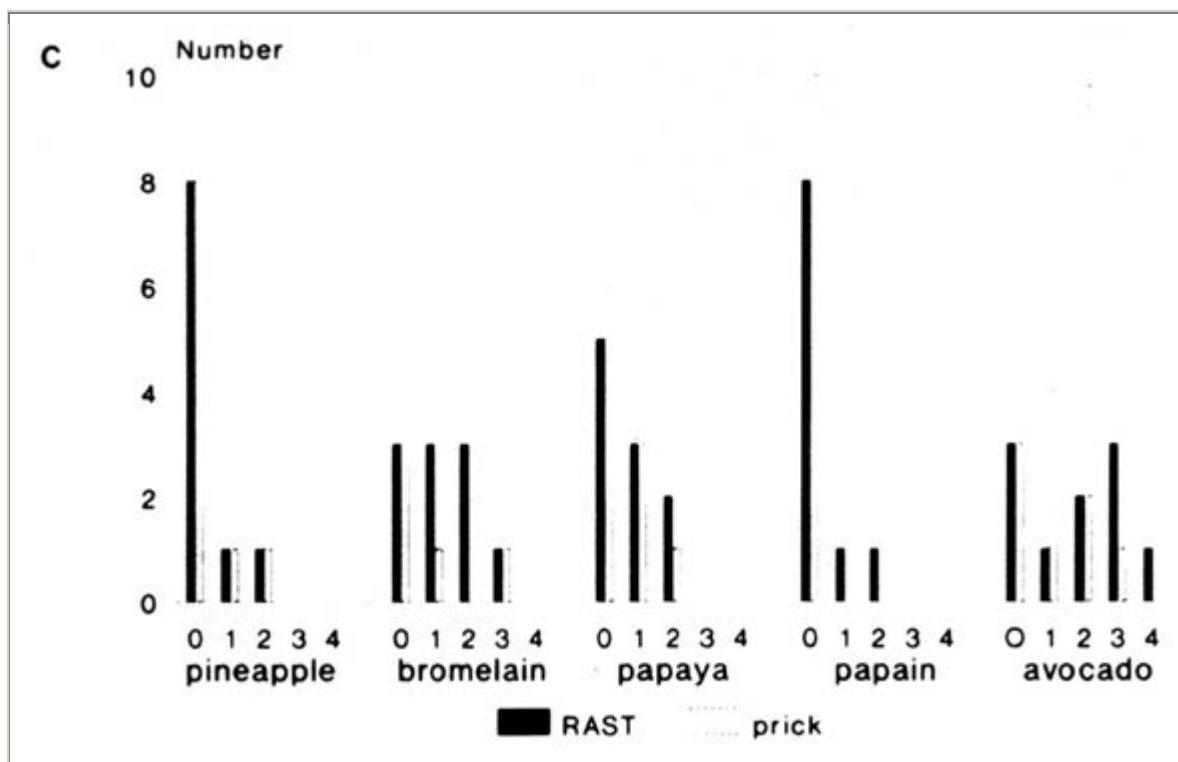
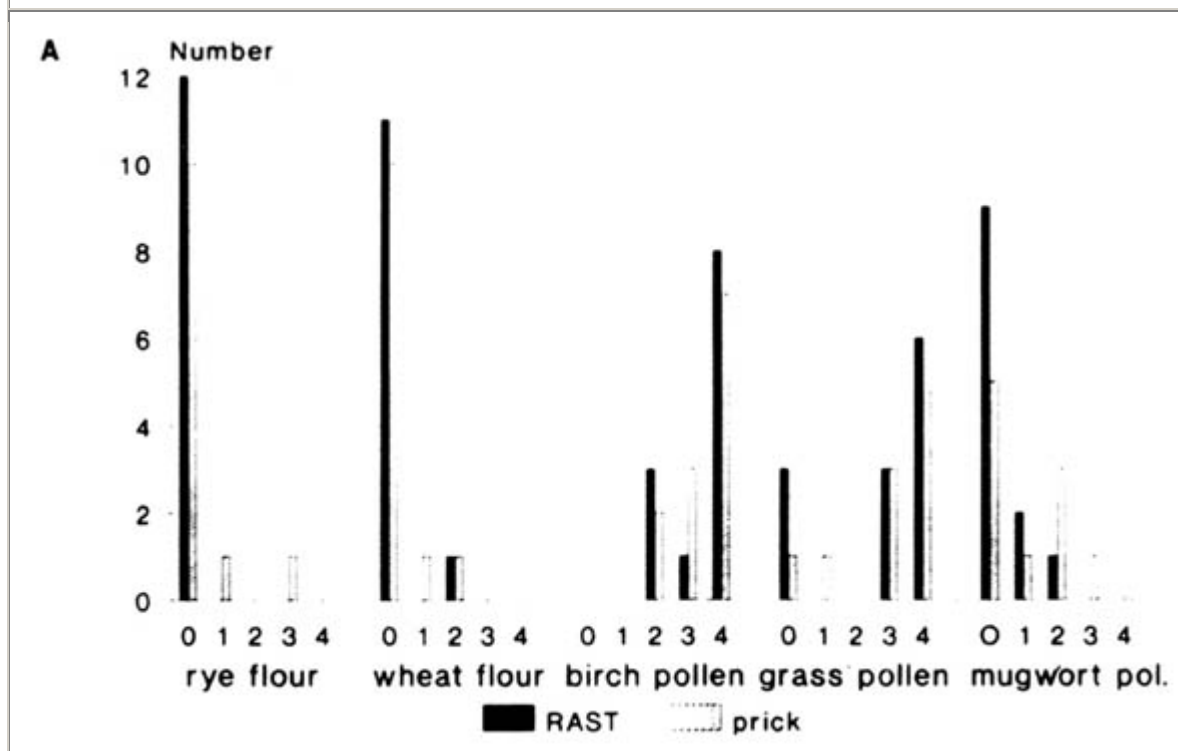
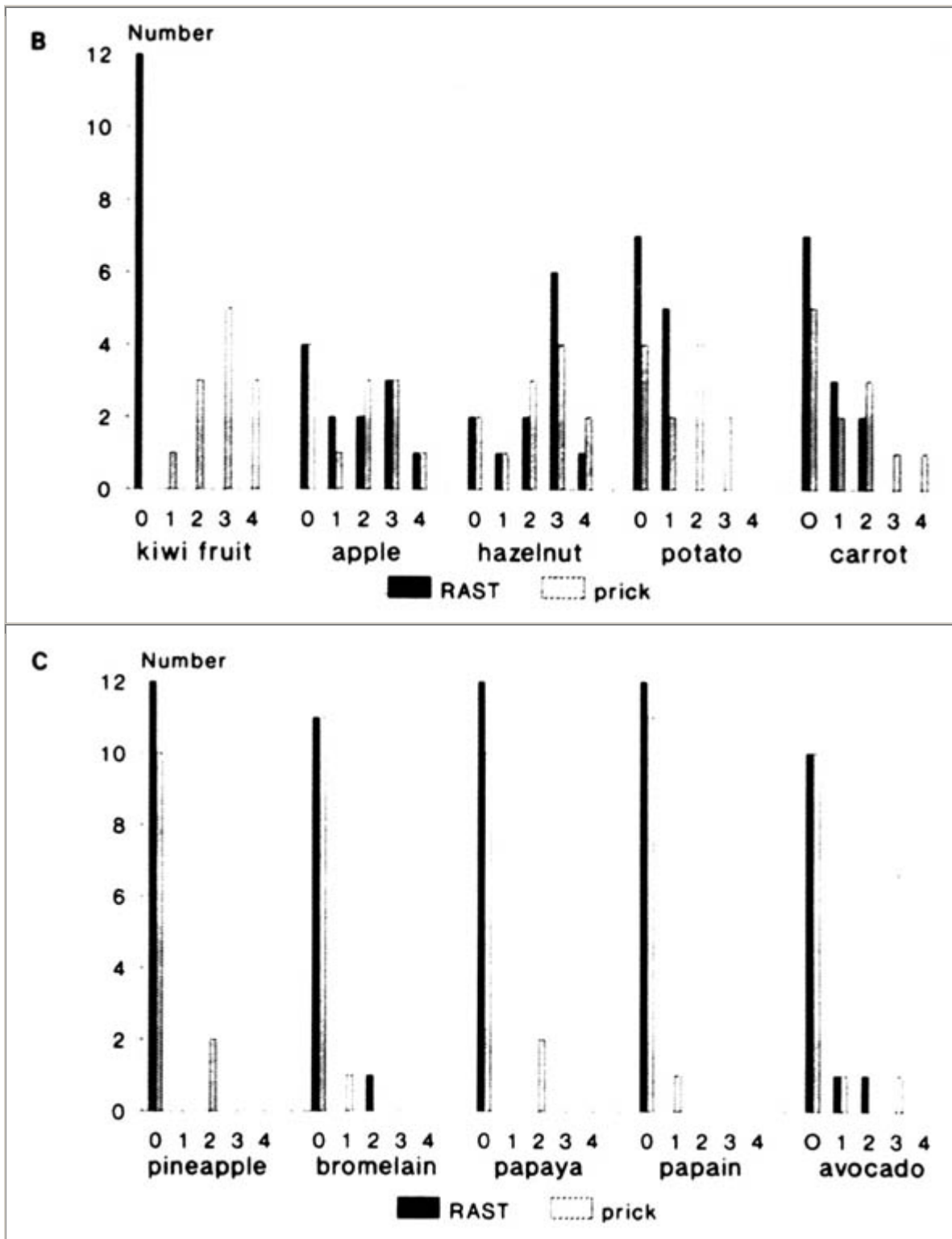


FIG. 2. Group 2: IgE values and skin test results in 12 patients with mild clinical symptoms after kiwi fruit ingestion. Scale of the IgE values: 0 = negative; the numbers 1 to 4 correspond to the RAST classes I to IV. Assessment of the skin test results: 0 = negative, 1 = +, 2 = ++, 3 = +++, and 4 = ++++.





Generally, patients with severe clinical symptoms showed stronger reactions to food antigens than those with mild localized symptoms. All 22 patients showed positive prick reactions to fresh kiwi. When other food antigens were tested, apple, hazelnut, potato, and carrot produced strong to moderate test reactions (■Fig. 1, B and ■Fig. 2, B). Because the nature of the kiwi allergen has not yet been identified, we included other fruits rich in thiol proteinases and purified proteinases, if available. We found weak test reactions to pineapple and papaya, as well as to their enzymes bromelain and papain, and moderate reactions to avocado (■Fig. 1, C and ■Fig. 2, C). Rye and wheat flour produced only weak reactions in our patients (■Fig. 1, A and ■Fig. 2, A).

The seven patients with isolated birch pollen allergy without clinical symptoms after kiwi ingestion, who served as a control group, showed in addition to strong test reactions to birch pollen, moderate reactions to fresh kiwi fruit (■Table I).

TABLE I. RAST and skin test results in seven patients allergic to birch pollen and without symptoms of allergy to kiwi fruit

Patient No.	Kiwi fruit	Birch pollen	Grass pollen	Mugwort pollen
1	0/ ++	III/ ++	II/ +++	0/0
2	0/ ++	II/ +++++	IV/ +++++	0/0
3	0/ +	IV/ +++++	I/0	0/0
4	0/ ++	II/ +++	IV/ +++++	0/0
5	0/ ++	IV/ +++	IV/ +++++	I/0
6	0/ +	I/ +++	0/0	0/0
7	0/ ++	III/ +++++	IV/ +++++	III/ ++

The thermolability of the kiwi fruit allergen was assessed in three patients. The test reactivity disappeared when the fruits were heated above temperatures of 80° C to 90° C (■Table II).

TABLE II. Skin test reactivity in kiwi fruit thermolability

Patient No.	Kiwi fruit				
	Fresh	40° C	60° C	80° C	90° C
1	++	++	++	(+)	0
2	+++	+++	++	+	0
3	++++	++++	++++	++	(+)

Specific IgE profiles in patients with kiwi allergy

Specific IgE to birch pollen could be detected in all 22 patients with kiwi allergy, and to additional pollen in the vast majority of cases (■Fig. 1, A and ■Fig. 2, A). Patients with severe clinical symptoms to kiwi fruit showed moderately elevated IgE levels in response to kiwi fruits, whereas those with mild localized symptoms had no detectable IgE to kiwi fruits (■Fig. 1, B and ■Fig. 2, B). Patients with birch pollen allergy who tolerated kiwi fruits clinically had no IgE to kiwi fruit (■Table I).

All patients showed elevated IgE levels to birch pollen and IgE to food allergen. High values were observed in response to apple and hazelnut; moderate values to potato, carrot, and avocado; and low values to rye and wheat flour, pineapple and papaya, and their enzymes bromelain and papain. Generally, those patients with severe clinical reactions to kiwi fruit showed higher IgE values than the group with mild reactions. This is best exemplified for birch pollen IgE (■Table III). It seems noteworthy that patients with kiwi allergy had higher IgE levels to birch pollen than patients with birch pollen allergy without signs of kiwi allergy.

TABLE III. Specific IgE profiles of birch pollen in clinical kiwi allergy

Grade of clinical symptoms after kiwi ingestion	Number	IgE values (%)	
		Median	Range
Severe	10	52.2	20-59
Mild	12	35	4.5-47
Total (severe + mild)	22	46.5	4.5-59
Patients allergic to birch pollen without symptoms	7	11	3.5-23

■ Table IV summarizes the results of RAST inhibition assays with other allergens. Most allergens tested were able to inhibit the kiwi RAST but differed in their inhibitory potential. Dilutions above 1 : 5 resulted in RAST inhibition of only pollen preparations, particularly in birch pollen, and of apple and potato in patient 2.

TABLE IV. RAST inhibition of kiwi fruit in three patients

	Patient 2	Patient 6	Patient 10
Kiwi fruit 20% (wt/vol)	1:1000	1:50	1:25
Pineapple 20% (wt/vol)	1:5	1:1	1:1-5
Bromelain 10 mg/ml	1:1	1:1	1:5
Papaya 20% (wt/vol)	1:1	1:1	1:1-5
Papain 10 mg/ml	NI	1:1	1:5
Avocado 20% (wt/vol)	1:2	ND	ND
Hazelnut 20% (wt/vol)	1:4	1:2	1:4
Apple 20% (wt/vol)	1:20	1:3	1:1-5
Potato 20% (wt/vol)	1:70	1:1	1:1-5
Carrot 20% (wt/vol)	1:1	NI	1:1-5
Rye flour 2.5%	1:4	1:2	1:5
Wheat flour 2.5%	1:2	1:2	1:5
Birch pollen 2.5%	1:1000	1:500	1:125
Grass pollen 2.5%	1:4	1:4	1:125
Mugwort pollen 2.5%	1:20	1:4	1:5

The dilution still resulting in at least 50% reduction of the specific IgE value is given.
NI, No inhibition; *ND*, not done.

Discussion

Increasing numbers of clinically relevant cross-reactivities between different type I allergens have been recognized during the past decade (■Table V).¹⁵⁻²¹ Patients with pollen allergy often experience, for example, allergic reactions to various fruits, vegetables, and nuts.

TABLE V. Pollen-associated food allergy

Pollen	Food	Reference
Ragweed	Melon, banana	Anderson et al. ¹⁵
Grass	Swiss chard	de la Hoz et al. ¹⁶
Grass	Tomato, peanut	de Martino et al. ¹⁷
Grass	Tomato, melon, watermelon	Ortolani et al. ¹⁸
Birch	Apple, carrot, potato	Dreborg and Foucard ¹⁹
Birch	Hazelnut, apple	Eriksson et al. ⁸
Birch	Apple, cherry, peach, pear	Calkhoven et al. ²⁰
Birch/mugwort	Celery, carrot	Wüthrich et al. ²¹

Although allergic reactions after the ingestion of kiwi fruit are well documented,¹⁻⁵ there are only few reports on cross-reactivities between kiwi fruit and other foods or pollen. Sabbah et al.⁶ observed two patients with kiwi allergy and associated allergy to birch pollen and apple. Eriksson⁸ found a weak correlation ($r = 0.6$) between kiwi allergy and avocado allergy in 600 patients with pollen allergy. A simultaneous occurrence of hazelnut and flour allergy was reported in eight patients with kiwi allergy,⁹ which was later shown to be due to cross-reactivities by means of RAST inhibition assays with hazelnut and rye flour.⁷ In a pilot study of four patients with kiwi allergy, we demonstrated cross-reactivities between kiwi fruit, birch pollen, and various foods.¹⁰ The aims of this study were to investigate the association of other type I allergies in a larger group of patients with kiwi allergy and to analyze possible immunologic cross-reactivities between kiwi and other allergens.

All 22 patients with allergic symptoms after the ingestion of kiwi, both the group with severe systemic reactions and the group with localized symptoms confined to oral and pharyngeal mucosa (oral allergy syndrome),¹⁸ showed positive prick test reactions to fresh kiwi. In contrast, specific IgE to kiwi was found only in patients with severe generalized reactions. From this we conclude that skin testing is more sensitive for detection of a possible kiwi allergy.

Kiwi fruit, like other tropical fruits, contains proteolytic enzymes: actinidin in kiwi fruit, bromelain in pineapple, and papain in papaya.²² These enzymes exhibit a weak sensitization potential. All enzymes are categorized as plant thiol proteinases, and they have common physical and chemical characteristics but differ in molecular weight and isoelectric point.²² Actinidin has been sequenced and shows a molecular weight of 12.8 kd.²³ By means of RAST and RAST inhibition assays, Baur²⁴ demonstrated cross-reactivities between bromelain and papain. These enzymes do not seem to be immunologically related to actinidin, since our data document only a weak cross-reactivity between actinidin (kiwi) and the other thiol proteinases, bromelain and papain.

The thermolability of many plant allergens has been well documented²¹ but has not been reported for kiwi fruit. We found that the kiwi allergen(s) are destroyed after heating above 80° C to 90° C.

In our patients kiwi allergy was associated in each case with clinically relevant birch pollen allergy and with allergy to other pollen in the majority of cases. A strong association was also found with allergies to various foods, such as apple and hazelnut, and a moderate association with allergies to potato and carrot. Sensitization without clinical relevance was seen with avocado, rye and wheat flour, pineapple and papaya, and their enzymes bromelain and papain. Our RAST inhibition studies show that these associations are at least partially due to immunologic cross-reactivities. The strongest inhibition of the kiwi RAST was produced by birch pollen. Grass and mugwort pollen, as well as apple and potato, could inhibit the kiwi RAST moderately. This indicates that birch pollen contains large quantities of the cross-reacting antigen, whereas the other allergens contain lower amounts.

It was interesting to see that patients with kiwi allergy showed much higher levels of IgE to birch pollen than those patients with clinical birch pollen allergy who did not experience allergic reactions to kiwi. Also, we were surprised to find higher IgE levels to birch pollen in patients who had generalized reactions after kiwi ingestion than in those with the oral allergy syndrome. From this and strong inhibition of the kiwi RAST by birch pollen, we conclude that patients with high concentrations of birch pollen IgE are at risk for developing allergic reactions to kiwi caused by cross reactions. Only in those patients with very high birch pollen IgE can IgE to kiwi be detected, whereas in our patients with oral allergy syndrome no IgE to kiwi was detectable. Our finding that patients with isolated birch pollen allergy also showed positive prick test reactions to kiwi further supports the view that birch pollen allergy precedes kiwi allergy. These clinical and in vitro observations put kiwi allergy on the list of birch pollen-associated food allergies.

Kiwi fruit enjoys increasing popularity, and allergic reactions were frequently observed in the past decade. The prevalence of sensitization to birch pollen, based on skin prick testing, is 9.2% evaluated in school children, aged 5 to 6, years.²⁵ In schoolchildren (mean age, 11 years) the prevalence is determined with 13.8% and increasing within 2 years in a follow-up study up to 19.8%.²⁶ Thus the prevalence of sensitization to birch pollen is relatively high in Germany. Because kiwi fruit allergy is most likely due to cross-reacting birch pollen IgE antibodies, we expect increasing numbers of allergic reactions to kiwi fruit in the future.

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A classification of plant food allergens

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Allergy to kiwi: A double-blind, placebo-controlled food challenge study in patients from a birch-free area

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Severe anaphylaxis to kiwi fruit: Immunologic changes related to successful sublingual allergen immunotherapy

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Isolation and biochemical characterization of a thaumatin-like kiwi allergen

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Marija Gavrović-Jankulović, PhD^a, Tanja Ćirković, MS^a, Olga Vučković, MD^b, Marina Atanasković-Marković, PhD^c, Arnd Petersen, PhD^d, Gordana Gojgić, PhD^a, Lidija Burazer, MS^b, Ratko M. Jankov, PhD^a

Molecular and biochemical classification of plant-derived food allergens

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