

Original article

The clinical relevance of sensitization to pollen-related fruits and vegetables in unselected pollen-sensitized adults

Background: Previous studies have described cross-reactivity between fresh fruits, vegetables and pollen. However, no data demonstrates the clinical relevance of sensitization to pollen-related fruits and vegetables in unselected pollen-sensitized adults with and without symptoms in the pollen season.

Objective: The aim of this study was to estimate the clinical relevance of sensitization to pollen-related fruits and vegetables in unselected pollen-sensitized adults and to examine the diagnostic value of skin-prick test (SPT), histamine release and specific IgE compared with the outcome of oral challenge.

Methods: In total, 936 unselected adults (female : male 479 : 457, median age 33.7 years) were examined for pollen sensitization and clinical cross-reactivity with pollen-related fruits and vegetables by questionnaire, SPT, histamine release, specific IgE and oral challenge.

Results: The prevalence of pollen sensitization was 23.8% ($n = 223$). The probability of a clinical reaction to pollen-related foods in the respective pollen-sensitized groups was: 24% (birch), 4% (grass), 10% (mugwort), 35% (birch + grass), 8% (grass + mugwort) and 52% (birch + grass + mugwort). The odds ratio of a clinical reaction to pollen-related fruits and vegetables in symptomatic pollen-sensitized adults was as high as four times (birch + grass) the odds ratio of a clinical reaction in asymptomatic pollen-sensitized adults.

Conclusion: This study not only demonstrates a high prevalence of clinical reactions to fruits and vegetables in pollen-sensitized adults, but also a discrepancy between the prevalence of sensitization to fruits and vegetables and the clinical relevance in different pollen-sensitized groups with symptoms in the pollen season as a significant factor.

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Key words: adults; birch; food hypersensitivity; grass; mugwort; pollen; prevalence; unselected.

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Clinical allergic reactions after intake of fresh fruits and vegetables are often reported in pollen-sensitized patients (1–7).

The symptoms mostly comprise the oral allergy syndrome (OAS), although severe allergic reactions are occasionally elicited (2, 8–12).

Previous studies have identified some of the most important pollen allergens sharing homologous IgE-binding sites with certain fruits and vegetables. The major allergen of birch pollen, Bet v 1, cross-reacts with homologous proteins in hazelnut, apple, soya bean, bell pepper and celery (13–22).

Profilin was first identified as a cross-reacting allergen of birch pollen, named Bet v 2, but now stated to be a panallergen of birch, grass and mugwort (23). Patients sensitized to pollen profilins cross-react with a wide range of fruits and vegetables including peanuts, hazelnut, celery, tomato, kiwi, soya beans and apple (14–16, 24–27).

The major allergens of grass pollen (Phl p 1, 2, and 5) are expressed in homologous proteins of tomato, kiwi, sunflower, wheat, corn and poppy seeds (27–31).

Mugwort and grass pollen contain a panallergen, Art v 1, leading to a significant number of cross-reactions with fresh fruits and vegetables (32–36).

Furthermore, it is well known that skin-prick testing (SPT) with fresh fruits and vegetables demonstrates a significant better diagnostic sensitivity than commercial extracts (4, 37–39).

The objective of this study was to determine the prevalence of sensitization to pollen-related foods and estimate the clinical relevance in unselected pollen-sensitized adults with and without symptoms during the pollen seasons and to examine the diagnostic value of SPT, histamine release from basophils (HR) and specific IgE compared with oral challenge.

Methods

Study population

The study population comprised 936 unselected adults (female : male 479 : 457, median age 33.7 years, range 21.8–58.8 years), all parents from a birth cohort (40).

Approval for this study was obtained from the local ethics committee (no. 20010088) and written informed consent was obtained from all subjects before enrollment in the study.

Diagnostic procedures

Self-reported allergic reactions after intake of pollen-related foods as well as symptoms in the pollen season (asthma and rhino-conjunctivitis) were recorded by questionnaire.

The adults were examined for pollen sensitization and sensitization to pollen-related fruits and vegetables by SPT, HR and specific IgE followed by oral challenge in adults with suspected (i.e. possible) clinical allergic reactions to pollen-related fruits and vegetables. Possible food hypersensitivity (FHS) was defined as self-reported allergic reactions (questionnaire), or a positive outcome in at least one of the test procedures (SPT, HR, specific IgE) without a clear-cut negative case history (not regularly eating the causative food during the last year).

Oral challenges were not performed when a positive test result was found together with a clear-cut negative case history (reporting intake of the respective food frequently without any symptoms).

Skin-prick test

Skin-prick test was performed by the prick–prick technique (4) with a selected panel of fresh fruits and vegetables including: peanut, soya bean, celery, corn, brazil nut, hazelnut, wheat, apple (Golden Delicious), orange, kiwi, sesame seeds, sunflower, poppy seeds, and pepper. SPT was also performed with inhalation allergens: pollen allergens (birch, grass and mugwort), horse, dog, cat, dust mites (*Dermatophagoides farinae* and *D. pteronyssinus*), *Cladosporium* and *Alternaria* (ALK-ABELLÓ, Hørsholm, Denmark).

Skin-prick test was performed with a 1-mm lancet (ALK-ABELLÓ) at the volar surface of the forearm with histamine dihydrochloride (10 mg/ml) and diluent used as positive and negative control, respectively (41). SPT was performed in duplicate according to the European Academy of Allergology and Clinical Immunology (EAACI) guidelines and wheals were evaluated after 15 min (4). The wheal reactions were outlined with a marker and transferred to paper with transparent tape.

The wheal size was measured using the formula: $(D + d)/2$, where D was the maximum diameter, and d its perpendicular diameter, and a positive SPT was defined as a wheal size ≥ 3 mm more than that of the negative control (41).

Laboratory studies

Histamine release from basophils. This test was performed by using a glass-fibre-based histamine assay including six allergen dilutions of each allergen in duplicate (<http://www.reflab.dk>) (42). A histamine release of ≥ 10 ng/ml was considered as positive.

Histamine release was analysed, to a selected panel of foods and pollen including: peanut, soya bean, wheat, celery, corn, brazil nut, hazelnut, apple, orange, tomato, kiwi, sesame seeds, poppy seeds, bell pepper (green), birch, grass and mugwort.

Determination of specific IgE. In the pollen-sensitized adults, specific IgE was determined to celery, wheat, peanut, kiwi, hazelnut, birch, grass and mugwort using the CAP technique (Pharmacia & Upjohn, Uppsala, Sweden) according the manufacturer's instructions (<http://www.pharmacia.com>). Measurable specific IgE was classified as a positive test result (i.e. CAP ≥ 0.35 kU_A/l).

Oral food challenge. An open controlled standardized food challenge (OCFC) was performed with kiwi, celery, corn, apple, brazilnut, bell pepper (green), sesame seeds, orange and tomato, whereas the double-blind placebo-controlled food challenge (DBPCFC) was performed with hazelnut, peanut and soya bean.

The double-blind placebo-controlled food challenge was performed by masking the foods (peanut, soya bean, and hazelnut) in chocolate bars using titrated doses of 0.5, 1, 4, 8, 16, 32 and 95 g with a converting factor of 0.16 (peanut), 0.15 (soya bean) and 0.16 (hazelnut) to the actual weight (g) of the respective foods.

The open controlled standardized food challenge was performed with the doses of 0.5, 1, 2, 4, 8, 16 and 32 g of the respective fresh fruits and vegetables. The dose interval was 15 min. A positive challenge was divided into immediate or late reactions. The immediate reactions were defined as a reaction occurring within 2 h after the last dose was administered, whereas late reactions appeared between 2 and 24 h after the last dose of the food had been administered.

Adults with a positive outcome in oral challenge were asked for late reactions by a telephonic interview and the symptoms reported were subsequently verified by clinical examination.

Statistics

The sensitivity is the proportion of positive cases that are correctly classified by the diagnostic tests (SPT, HR and CAP), whereas the specificity is the proportion of negative cases correctly classified by the diagnostic tests (43).

The positive predictive value (PPV) and the negative predictive value (NPV) are the likelihood that a positive and negative test result reflects the presence or absence of clinical cross-reactivity.

The overall prevalence of clinical relevance of sensitization to pollen-related foods was calculated by assuming that the proportion with a positive outcome in oral challenge was identical to the part not challenged among the adults. Thus, the proportion with clinical relevance was estimated as the number of positive challenges divided into the total number of challenges.

The clinical relevance of sensitization to certain pollen-related foods in the different pollen groups was estimated as: numbers of positive challenges to the respective food/total numbers of challenges with the respective food * numbers with possible FHS to the respective food/numbers in the respective pollen group * 100%.

The outcome of SPT (inhalation allergens, food allergens) and distribution of the sex were compared between the challenged and non challenged group by the two-sided Fisher exact test, whereas the Mann–Whitney non-parametric test was used to examine a possible significant difference in the age (43). Values were considered significant at the $P < 0.05$ level.

The receiver-operating characteristics (ROC) was used to quantify the accuracy of the diagnostic tests (SPT, HR and CAP) to discriminate between a positive and negative outcome in oral challenge. The greater the area under the curve, the better performance of the diagnostic test.

All statistical analyses were performed with Stata 8.1 (Stata corporation, College Station, TX, USA).

Results

Skin-prick tests were performed in 757 (81%) of 936 adults. In total, 223 (23.8%) adults were sensitized to pollen (SPT) with 161 (72%) reporting symptoms during the pollen season. A blood sample was obtained from 198 (89%) of the 223 pollen-sensitized adults.

In total, 94 pollen-sensitized adults presented possible allergy to fruits and vegetables, whereas 129 pollen-sensitized did not report food allergy (i.e. regularly eating the respective fruits and vegetables without any symptoms).

The clinical relevance of sensitization to pollen-related fruits and vegetables were investigated by 153 oral challenges (125 OCFCs and 28 DBPCFCs) in 71 of 94 pollen-sensitized adults with a possible clinical allergic reaction to the respective fruits and vegetables. In total, 54 of 71 adults were positive (immediate reactions) in oral challenge to one or more pollen-related foods. There was no statistically significant difference between the challenged ($n = 71$) and non-challenged ($n = 23$) pollen group concerning sensitization to inhalation allergens ($P = 1.00$), food allergens ($P = 1.00$), sex ($P = 0.34$) and age ($P = 0.41$), making a converting factor of 0.76 (54/71) valid for estimating the clinical relevance of sensitization to pollen-related foods in the respective pollen-sensitized groups.

Table 1 lists the performance characteristics of oral challenges with OAS as the most frequently elicited symptom.

The main reasons for not being tested (SPT, blood sample and oral challenge) were living too far away from the hospital, lack of time or fear of having a blood test or SPT performed.

Tables 2–4 list the performance characteristics of a positive SPT, CAP or HR to pollen-related fruits and vegetables in pollen-sensitized adults and the clinical relevance in the different pollen groups.

Sixty-one (27%) adults were monosensitized to grass pollen with a strikingly low (4%) clinical relevance of sensitization to fruits and vegetables compared with adults monosensitized to birch pollen, where 24% presented a clinical reaction after intake of related foods (Table 2). The clinical relevance of sensitization to pollen-related foods in adults sensitized to both birch + mugwort pollen (0%) or grass + mugwort pollen (8%) was different from the clinical relevance when sensitized to birch + grass pollen (35%) (Table 2). In adults sensitized to all three pollen (birch + grass + mugwort), the proportion sensitized to fruits and vegetables (89%) and their clinical relevance was higher (52%) than in the other pollen groups (Table 2).

Hazelnut, kiwi, apple (Golden Delicious) and celery root were responsible for the majority of the fruits and vegetables eliciting an allergic reaction in the pollen-sensitized adults (Table 2). No allergic reactions to poppy seeds, soya bean, sunflower and wheat were found, although a significant number of the adults were SPT-positive to the respective foods (Table 2).

Figure 1 shows the clinical relevance of sensitization (SPT) to pollen-related fruits and vegetables in the different pollen groups with and without symptoms during the pollen season. Overall, the odds ratio for a clinical allergic reaction to pollen-related foods in symptomatic pollen-sensitized adults was 3.3 (P -value = 0.003) compared with asymptomatic pollen-sensitized adults. The odds ratios for a clinical reaction to fruits and vegetables in symptomatic versus asymptomatic

Table 1. The performance characteristics of case history and oral challenges in pollen-sensitized adults

Food	Case history		Oral challenge					
	+ case	? case	No	Positive	OAS	As	U	RC
Apple*	41	2	30	26	26	–	2	1
Brazilnut	0	26	10	6	6	–	–	–
Celery	5	18	15	11	11	1	1	–
Corn	0	0	0	–	–	–	–	–
Hazelnut	50	12	45	31	31	–	–	–
Kiwi	29	17	28	18	18	–	1	–
Orange	12	0	5	2	2	–	2	–
Peanut	6	3	9	2	2	–	–	1
Bell pepper	3	3	2	2	2	–	–	–
Tomato	11	3	5	4	4	–	–	–
Sesame	1	4	2	2	2	–	–	–
Soy	0	2	2	0	–	–	–	–

Case history: +, positive case history; self-reported food hypersensitivity in the questionnaire or questionable case history; a positive test (skin-prick test, histamine release or CAP) without a clear cut negative case history (not regularly eating the causative food during the last year).

Oral challenge: no., number of oral challenges performed with the respective food; positive, number of adults with a positive outcome in oral challenge.

Symptoms elicited during oral challenge; OAS, oral allergy syndrome; As, asthma; U, urticaria; RC, rhino-conjunctivitis.

* Golden Delicious.

Table 2. The performance characteristics of a positive skin prick test to fruits and vegetables and the clinical relevance (%) in different pollen-sensitized groups

Food	B (n = 28)		G (n = 61)		M (n = 8)		B+G (n = 56)		B+M (n = 6)		G+M (n = 19)		B+G+M (n = 45)	
	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R
Apple	36	9	3	0	0	0	39	19	0	0	5	0	53	33
Brazil nut	4	0	3	0	0	0	13	2	0	0	11	0	24	5
Celery	7	3	3	0	13	9	23	8	0	0	11	4	38	10
Corn	0	0	5	0	0	0	9	0	0	0	5	0	16	0
Hazelnut	57	20	11	0	0	0	70	25	50	0	5	0	80	37
Kiwi	25	7	13	3	0	0	43	15	0	0	21	3	67	21
Orange	11	1	2	0	0	0	16	1	0	0	5	0	38	4
Peanut	11	0	2	0	0	0	14	0	0	0	5	0	16	0
Bell pepper	7	4	0	0	0	0	4	0	0	0	5	0	13	2
Poppy seeds	0	0	3	0	0	0	13	0	0	0	16	0	24	0
Sesame seeds	4	0	3	0	0	0	11	0	0	0	11	0	29	2
Soy	21	0	10	0	0	0	38	0	0	0	21	0	53	0
Sunflower	18	0	13	0	13	0	27	0	0	0	26	0	44	0
Wheat	4	0	13	0	0	0	29	0	0	0	21	0	38	0
Total*	61	24	39	4	13	10	75	35	50	0	53	8	89	52

B, birch; G, grass; M, mugwort.

Sen., sensitized, i.e. a positive skin-prick test to the respective food in percent of the respective pollen group.

C-R, clinical relevance (%) estimated by: total numbers with a positive oral challenge to the respective food/total numbers of oral challenges performed with the respective food * numbers with possible secondary FHS to the respective food/numbers in the respective pollen group * 100%; apple (birch) 26/30 * 3/28 = 9%.

Total: clinical relevance estimated from: total number of adults with a positive oral challenge (n = 54)/number of challenged adults (n = 71) * numbers with possible secondary FHS in the respective pollen group/numbers in the respective pollen group * 100%.

Table 3. The performance characteristics of a positive specific IgE response to fruits and vegetables and the clinical relevance in certain pollen-sensitized groups

Food	B (n = 25)*		G (n = 49)		M (n = 5)		B + G (n = 51)†		B + M (n = 5)‡		G + M (n = 18)§		B + G + M (n = 38)¶	
	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R
Celery	—	—	—	—	40	15	—	—	0	0	28	0	53	10
Hazelnut	13	6	—	—	—	—	14	8	0	0	—	—	18	11
Kiwi	0	0	—	—	—	—	8	3	0	0	—	—	3	0
Peanut	—	—	2	0	—	—	26	0	—	—	13	0	37	3
Wheat	—	—	6	0	—	—	24	0	—	—	22	0	29	0

B, birch; G, grass; M, mugwort.

Sen., sensitized, i.e. a positive skin-prick test to the respective food in percent of the respective pollen group.

C-R, clinical relevance (%) estimated by: total number a with positive oral challenge to the respective food/total number of oral challenges performed with the respective food * numbers with possible secondary FHS to the respective food/numbers in the respective pollen group * 100%.

* Hazelnut; n = 24.

† Kiwi n = 48 and peanut n = 50.

‡ Kiwi n = 4.

§ Peanut n = 16.

¶ Kiwi n = 37.

—, not analysed by CAP in the respective pollen group.

pollen-sensitized adults were: birch (3.7), grass (1.2), birch + grass (4) and birch + grass + mugwort (3.1).

Table 3 shows the relationship between sensitization to pollen-related foods and the clinical relevance investigated by specific IgE (CAP) in certain pollen groups. The prevalence of sensitization to peanut varied in the different pollen groups between 2% (grass) and 37% (birch + grass + mugwort), however, with a low clinical relevance (Table 3).

Table 4 lists the performance characteristics in adults with a positive HR to pollen-related foods in the different

pollen groups. The prevalence of sensitization to pollen-related food was higher when using HR compared with SPT (Tables 2 and 4). However, the clinical relevance in adults sensitized to fruits and vegetables by HR was similar to SPT in the different pollen groups except for grass and birch + mugwort (Tables 2 and 4).

Table 5 lists the diagnostic value of SPT, CAP and HR compared with outcome of oral challenge. The sensitivity varied between 0% (peanut) and 100% (orange) using SPT, 0% (orange) and 100% (celery) using HR, and 13% (kiwi) and 50% (peanut) using CAP. PPV was low for all

Table 4. The performance characteristics of a positive histamine release to fruits and vegetables and the clinical relevance in different pollen-sensitized groups

Food	B (n = 25)		G (n = 50)		M (n = 8)		B+G (n = 53)		B+M (n = 5)		G+M (n = 18)		B+G+M (n = 39)	
	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R	Sen	C-R
Apple	28	10	12	0	0	0	43	21	0	0	0	0	49	36
Brazil nut	28	7	28	2	25	8	47	11	0	0	39	3	51	12
Celery	52	9	36	1	13	0	42	12	60	15	61	4	77	13
Corn	4	0	22	0	13	0	45	0	0	0	39	0	46	0
Hazelnut	40	17	4	0	13	0	45	22	0	0	0	0	54	35
Kiwi	24	8	34	1	13	0	34	8	40	0	17	0	51	18
Orange	4	0	4	0	25	0	8	1	0	0	0	0	8	0
Peanut	28	0	34	0	25	0	58	0	20	0	39	6	69	3
Pepper	20	4	18	0	25	13	32	0	40	0	33	0	64	8
Poppy seeds	4	0	4	0	0	0	4	0	0	0	11	0	5	0
Sesame seeds	8	0	24	0	13	0	25	2	0	0	6	0	33	8
Soy	12	0	4	0	0	0	26	0	0	0	17	0	26	0
Tomato	12	0	20	2	0	0	15	2	40	16	11	4	31	6
Wheat	12	0	10	0	13	0	30	0	0	0	39	0	31	0
Total*	85	33	70	8	50	10	91	34	100	15	78	8	92	55

B, birch; G, grass; M, mugwort.

Sen., sensitized, i.e. a positive histamine release to the respective food in percent of the respective pollen group.

C-R, clinical relevance (%) estimated by: total numbers a with positive oral challenge to the respective food/total numbers of oral challenges performed with the respective food * numbers with possible secondary FHS to the respective food/numbers in the respective pollen group * 100%; apple (birch) 26/30 * 3/25 = 10%.

Total: clinical relevance estimated from: total number of adults with a positive oral challenge (n = 54)/numbers of challenged adults (n = 71) * numbers with possible secondary FHS in the respective pollen group/numbers in the respective pollen group * 100%.

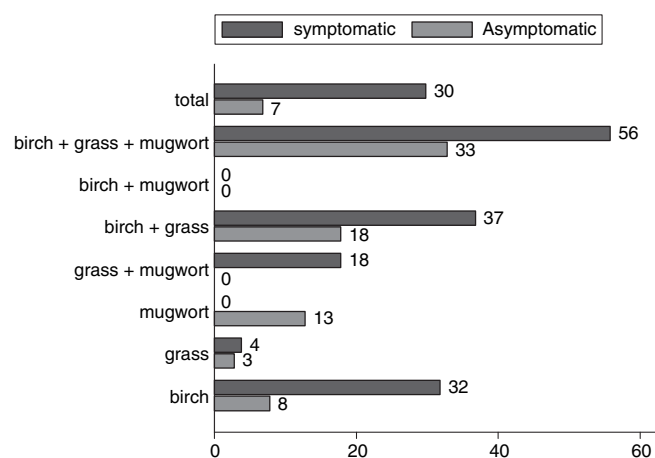


Figure 1. The probability (%) of a clinical reaction to pollen-related foods in symptomatic and asymptomatic pollen-sensitized adults.

selected foods and test procedures; however, the NPV was high (83–100%) (Table 5).

Figure 2 shows an example of a ROC curve with HR for hazelnut. The ROC areas (under the curve) are listed in Table 5 for the respective foods and tests.

In general, CAP was not useful in discriminating between a positive and negative outcome of oral challenge for celery, hazelnut and kiwi in pollen-sensitized adults. However, SPT and HR showed useful diagnostic values (sensitivity, specificity and negative predictive value) for the included fruits and vegetables, except for orange (HR) and peanut (SPT).

Table 5. The diagnostic value of skin prick test, histamine release and specific IgE (CAP) in pollen-sensitized adults

Food	Test	Sensitivity	Specificity	PPV	NPV	ROC area
Apple	SPT	73	83	46	94	0.81
Apple	HR	85	85	53	96	0.85
Brazil nut	SPT	50	92	32	96	0.71
Brazil nut	HR	83	68	16	98	0.79
Celery	SPT	73	88	33	98	0.88
Celery	HR	100	55	15	100	0.83
Celery	CAP	27	69	7	92	0.49
Hazelnut	SPT	87	66	38	93	0.84
Hazelnut	HR	81	85	56	95	0.84
Hazelnut	CAP	19	91	33	83	0.55
Kiwi	SPT	76	75	32	95	0.81
Kiwi	HR	65	71	26	93	0.70
Kiwi	CAP	13	97	40	88	0.54
Orange	SPT	100	89	72	100	0.97
Orange	HR	0	94	0	98	0.47
Peanut	SPT	0	91	0	99	0.42
Peanut	HR	100	53	2	100	0.71
Peanut	CAP	50	84	3	99	0.69

SPT, skin-prick test; HR, histamine release from basophils; CAP, specific IgE measured with CAP; PPV, positive predictive value; NPV, negative predictive value; ROC area, area under the ROC curve, the greater area the better diagnostic accuracy of the respective test.

Discussion

This study demonstrates the prevalence of sensitization to fruits and vegetables and their clinical relevance in unselected pollen-sensitized adults with and without pollen symptoms during the season. We found a discrepancy

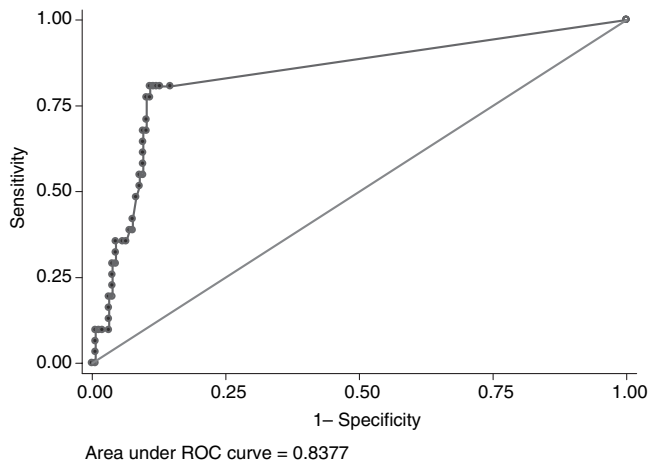


Figure 2. ROC curve for hazelnut in pollen-sensitized adults using histamine release.

between sensitization to fruits and vegetables and the probability of a clinical reaction in the different pollen groups. The probability of a clinical reaction to one or more fruits and vegetables was highest (52%) in adults sensitized to all three pollen (birch + grass + mugwort). Moreover, the odds ratio for a clinical reaction to pollen-related fruits and vegetables in symptomatic pollen-sensitized adults was up to four times the odds ratio in adults without pollen symptoms.

Bircher et al. (1) found that 39% of symptomatic pollen allergic patients reported (questionnaire) an allergic reaction after intake of one or more pollen-related fruits and vegetables compared to 30% in this study. Although, 30% in this study presented a clinical reaction after intake of pollen-related foods, the probability of an allergic reaction varied between 0% (birch + mugwort) and 52% (birch + grass + mugwort) (Fig. 1). This emphasizes the importance of stratification in different pollen groups (with and without symptoms) in predicting the clinical relevance of sensitization to pollen-related foods.

Ebner et al. (44) reported that 75.9% of selected birch pollen allergic patients presented clinical symptoms (questionnaire) after intake of apples, whereas Hannuksela and Lahti (45) found 23% of selected birch pollen-sensitized patients with a clinical reaction (case history) to apple compared with 9% in this study. However, we investigated unselected pollen-sensitized adults and ascertained clinical relevance by oral challenge. Moreover, both the abovesaid studies provide no information about sensitization to grass or mugwort pollen which has a significant importance as demonstrated in our study (44, 45).

Eriksson (2) reported a lower proportion of clinical relevance of sensitization to pollen-related foods in selected patients monosensitized to grass pollen compared to monosensitization to birch pollen, similar to the results in this study.

The panallergen Art v 1 as demonstrated by Hirschwehr et al. (34) may be the explanation of the major difference between the sensitization pattern to fruits and vegetables in adults sensitized to grass and grass + mugwort pollen.

Fifty per cent of the birch + mugwort group were sensitized to hazelnut (Table 2). The strong influence of the major allergens of birch pollen may not be the only explanation as an immunologic relation between mugwort pollen and hazelnut has been described by Cabarello et al. (35). The major allergen in poppy seeds seems to cross-react only with grass and not mugwort or birch pollen. The major allergen (45 kDa) detected by Jensen-Jarolim et al. (46) may be responsible for this cross-reactivity.

The poor sensitivity of SPT to peanut may be due to a loss of peanut allergen during extract preparation. Ortolani et al. (37) reported a better sensitivity with commercial peanut extract compared to fresh peanut. However, Rance et al. (38) reported a sensitivity of 90% using fresh peanut.

In this study, the sensitivity of CAP to kiwi, hazelnut and celery was estimated to be 13, 19 and 27%, respectively (Table 5). Ortolani et al. (47) and Ballmer-Weber et al. (48) reported a sensitivity of 75 and 96% to hazelnut and celery, respectively. Our results are in agreement with those of Wensing et al. (49), who reported a sensitivity on 35% using a cut-off level of 0.7 KU_A/l. This study population consisted of unselected adults and thereby a lower mean specific IgE concentration (CAP) of hazelnut. However, this cannot divert the fact of a very poor sensitivity for the respective foods using CAP.

In this study, the sensitivity was high using HR (except for orange), although the PPV was low as the other test procedures. Anhoj et al. (10) reported a high PPV (up to 91% for nuts) compared with 56% in this study. This discrepancy could be a result of different study populations as this study population comprised a large number of participants without food allergy compared with the study population in Anhoj et al. (10).

In conclusion, this study demonstrates the importance of stratification in different pollen groups (with and without symptoms) in predicting the clinical relevance of sensitization to pollen-related foods.

Thus, the highest probability (56%) of a clinical reaction after intake of relevant pollen-related fruits and vegetables was found in adults sensitized to birch + grass + mugwort pollen and having symptoms in the pollen season.

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