

Comparative study of commercial food antigen extracts for the diagnosis of food hypersensitivity

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Single lots of food allergen extracts from three different commercial sources were compared for their efficacy in evaluating immediate food hypersensitivity. Eighty-seven children with atopic dermatitis and food hypersensitivity underwent prick skin testing to a battery of 18 food extracts from each company. Results of skin tests were compared with results of double-blind, placebo-controlled oral food challenges and open challenges to determine the sensitivity, specificity, and predictive indices of each reagent. Negative predictive indices were generally good for all reagents, whereas positive predictive indices were generally poor and showed considerable variation (0% to 79%) between commercial sources. Under the conditions of the study, skin test reagents from two companies showed slightly better agreement with double-blind, placebo-controlled food challenge results than did reagents from the third company. However, with known lot-to-lot variations in extract potency and inpatient variation in skin test results, these differences probably are not of clinical significance. (J ALLERGY CLIN IMMUNOL 1988;82:718-26.)

Skin testing has been utilized for more than 100 years in the evaluation of allergic disorders. Today, several different methods of skin testing are practiced and many different commercial sources of antigen extracts are available to the practicing allergist. However, standardization of extract content and validation of the individual reagents are lacking. Nevertheless, skin testing remains the most popular diagnostic tool for evaluating food allergy, although several investigators have reported that skin tests alone are unreliable indicators of symptomatic hypersensitivity.¹⁻⁵

In an earlier study of 40 children with atopic dermatitis,⁶ results of skin prick tests and RASTs to food allergens were compared with results of DBPCFCs. Skin prick tests alone were found to be as efficacious

Abbreviations used

DBPCFC:	Double-blind, placebo-controlled oral food challenge
TP:	True positive
TN:	True negative
FP:	False positive
FN:	False negative

as RASTs or the combination of RAST plus skin tests in predicting food hypersensitivity. This study expands the earlier observations and compares the efficacy of three different commercial sources of food allergen extracts.

MATERIAL AND METHODS

Subjects

Eighty-seven patients ranging in age from 3 to 27 years (median 7.9 years) were enrolled in the study. All patients fulfilled the criteria of Hanifin and Rajka⁷ for the diagnosis of atopic dermatitis. In addition, 50% of the subjects had allergic rhinitis and asthma, 20% had allergic rhinitis, and 10% had asthma; 85% had elevated total serum IgE concentrations. All studies were approved by the Duke University Human Investigations Committee.

Procedures

Patients were admitted to the Clinical Research Unit for evaluation of food hypersensitivity. After reviewing the medical history and results of previous skin tests or RASTs,

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patients or their parents were instructed to eliminate all foods suspected of eliciting allergic symptoms for 1 to 2 weeks before admission. In addition, all patients were told to discontinue antihistamines for 7 to 10 days and β -adrenergic agonists for 12 hours before admission.

As listed in Table I, standard batteries of 18 glycerinated food extract reagents (1:10 or 1:20) were kindly supplied by Allergy Labs of Ohio (Columbus, Ohio), Greer Laboratories (Lenoir, N.C.), and Hollister-Stier (Spokane, Wash.). The histamine standard (2.75 mg/ml) used for the positive control was obtained from Greer Laboratories. Skin test materials were applied to the patients' backs by the prick technique. All tests were applied and measured by the same nurse clinician throughout the study. The mean diameters of the wheal-and-flare response were recorded as described by Voorhorst and van Krieken.⁸ Skin testing was performed in two to three sessions between 8:30 AM and 2:30 PM. The order in which the standard food battery from each commercial source was applied was varied to minimize "potential" diurnal variations in skin reactivity for the group.^{9,10} However, a recent study showed no significant difference in skin test reactivity during normal working hours.¹¹ Antigens eliciting a wheal ≥ 3 mm of the negative control were considered positive.

Any food previously implicated by allergy testing (skin test or RAST) or patient history as a possible allergen was tested by DBPCFC to rule out food hypersensitivity, irrespective of skin test results obtained in the study. Foods eliciting positive skin test results in the study that had been ingested in isolation with no apparent difficulty were tested by open challenge under observation in the research unit. Foods eliciting negative skin test reactions and not implicated as potential allergens by history were evaluated by open challenge in the research unit.

As previously described,² DBPCFC consisted of administering up to 8 to 10 gm of dehydrated, powdered food in opaque capsules or juice over a 1-hour period. A challenge was considered positive when objective cutaneous, nasal, pulmonary, or gastrointestinal symptoms occurred within 2 hours of the oral challenge. No isolated delayed reactions were seen. All negative results of blinded challenges were confirmed by subsequent open challenge. Open challenges consisted of feeding the test food in approximately twice the quantity normally consumed at a meal based on the child's age.

Statistics

Results of the food challenges were considered the "gold standard" for determining the presence of immediate food hypersensitivity. Sensitivity, specificity, and predictive accuracy¹² were determined for only nine food antigens (egg [egg white], peanut, milk, soy, wheat, fish, beef, pork, and chicken) because the numbers of food-sensitive individuals to the other nine foods were insufficient to calculate meaningful parameters. The sensitivity of the skin prick tests was calculated by dividing the number of positive food challenges correctly identified by the skin test (TP) by the total number of positive food challenges (TP + FN). Specificity was calculated by dividing the number of negative food challenges correctly identified (TN) by the total number of

TABLE I. Standard battery of food allergens used for skin prick testing

	No. of positive DBPCFC
Egg	42
Soy	6
Beef	2
Oats	0
Green bean	0
Corn	0
Peanut	23
Wheat	2
Pork	1
Rye	0
Potato	1
Shrimp	1
Milk	11
Fish	11
Chicken	2
Green pea	0
Rice	0
Tomato	0

negative challenges (TN + FP). The accuracy of skin tests was judged solely by "clinical relevance"; i.e., an FP skin prick test was followed by a negative food challenge and an FN result was followed by a positive food challenge. Therefore, the designation FP does not necessarily imply the presence of "immunologically" irrelevant antibody, but rather the absence of clinically relevant symptoms.

Indices of predictive accuracy, which are more pertinent to the clinical setting, were also calculated. The positive predictive accuracy was calculated by dividing the number of positive food challenges correctly identified by the skin test by the total number of positive skin tests. Likewise, the negative predictive accuracy was determined by dividing the number of negative food challenges correctly identified by the total number of negative skin tests. Two-by-two contingency tables were constructed to compare the number of correct predictions for each company's test antigen. Differences in the ability to correctly predict clinical hypersensitivity were then compared statistically with the McNemar test for paired alternatives with the use of a correction factor for small sample size.

Data were managed and analyzed with CLINFO.

RESULTS

The 87 patients in this study had 102 reactions to foods; 87 of the food hypersensitivities were confirmed by DBPCFC and 15 were based on a "convincing" history. A history was considered convincing only when a patient met the following criteria: (1) a potentially life-threatening allergic reaction (laryngeal edema, marked wheezing with severe dyspnea, or hypotension) occurred within 15 to 30 minutes after the isolated ingestion of a food and required "appropriate"

TABLE II. Results of skin prick tests to commercial extracts in study patients

Antigen	Parameter	ALO	Gr	H-S
Egg	TP	37	38	38
	FN	4	4	2
	TN	31	31	30
	FP	10	11	12
Egg white	TP	33	32	—
	FN	2	5	—
	TN	29	28	—
	FP	12	12	—
Peanut	TP	21	22	20
	FN	2	1	2
	TN	40	36	34
	FP	8	16	18
Milk	TP	8	10	9
	FN	3	1	2
	TN	62	68	60
	FP	12	8	13
Fish	TP	11	11	10
	FN	0	0	0
	TN	51	56	45
	FP	12	9	17
Soy	TP	3	5	6
	FN	3	1	0
	TN	70	57	50
	FP	9	24	29
Wheat	TP	2	2	2
	FN	0	0	0
	TN	71	74	60
	FP	11	11	20
Beef	TP	1	2	2
	FN	0	0	0
	TN	63	72	61
	FP	15	9	19
Chicken	TP	1	0	1
	FN	1	2	0
	TN	71	73	55
	FP	8	11	18
Pork	TP	1	1	1
	FN	0	0	0
	TN	52	61	49
	FP	25	23	29

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories; H-S = Hollister-Stier Laboratories.

emergency room management for anaphylaxis, (2) a skin test to the food in question was positive, and (3) the reaction must have occurred within 3 years of the study. Five of the patients diagnosed by "convincing" history had a second accidental ingestion, and one was intentionally challenged; all experienced similar

anaphylactic reactions. Because all six patients fulfilling these strict criteria reacted on rechallenge, it is highly likely that "convincing history" accurately reflects clinical sensitivity.

Symptoms elicited by the challenges reflected a variety of target organ responses in the skin, (ery-

TABLE III. Median value of
"mean diameters"*

Antigen	ALO	Gr	H-S
Egg	6	7	7
Peanut	6	15	7
Milk	4	5	5
Fish	3	5	4
Soy	2	3	4
Wheat	2	3	3
Beef	3	3	3
Chicken	2	2	3
Pork	3	3	3

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories;
H-S = Hollister-Stier Laboratories.

*All food antigens eliciting a wheal ≥ 1 mm are included in computation of the median value.

thematous, pruritic morbilliform rash or urticaria), eye (pruritus, tearing, conjunctival erythema), nose (nasal congestion, pruritus, rhinorrhea, and sneezing), mouth (tongue and palatal itching), larynx (edema, "tightness," "throat clearing," and cough), lung (wheezing and cough), and gastrointestinal tract (nausea, abdominal pain, vomiting, and diarrhea). All reactions occurred within 2 hours of ingestion of the challenge food and no isolated late reactions were seen. No patient developed symptoms to the "placebo" portion of the challenge.

There were sufficient numbers of positive food challenges and skin prick test results to analyze the food antigens indicated in Table II. The total number of positive skin tests for each commercial extract may be ascertained by adding TP + FP. Conversely, the total number of negative skin tests may be determined by adding TN + FN. Similarly, the total number of positive food challenges in patients tested with each commercial extract may be determined by adding TP + FN; likewise, total negative challenges are indicated by adding TN + FP.

Table III indicates the median wheal size for each company's food extract. Each food extract elicited similarly sized wheal responses except for Greer Laboratories' peanut extract, which yielded a significantly greater wheal size for the patient group. However, this larger wheal response did not translate into a more accurate predictive test reagent. Several patients experienced a late-phase skin test response. However, because this was not evaluated in a systematic fashion in all patients, the prevalence of late-phase responses cannot be determined.

The sensitivity, specificity, positive predictive accuracy, and negative predictive accuracy are compared for each company's food extract in Table IV.

TABLE IV. Descriptive value of prick
skin test*

Antigen	Parameter	ALO	Gr	H-S
Egg (50%)	s	90	91	95
	f	76	74	71
	v	79	78	76
Egg white	g	89	89	94
	s	94	87	—
	f	71	70	—
Peanut (31%)	v	73	73	—
	g	94	85	—
	s	91	96	91
Milk (13%)	f	83	69	65
	v	72	58	53
	g	95	97	94
Fish (15%)	s	73	91	82
	f	84	90	82
	v	40	56	41
Soy (7%)	g	95	99	97
	s	100	100	100
	f	81	86	73
Wheat (2.3%)	v	48	55	37
	g	100	100	100
	s	50	83	100
Beef (2.1%)	f	89	70	63
	v	25	17	17
	g	96	98	100
Chicken (2.1%)	s	100	100	100
	f	87	87	75
	v	15	15	9
Pork (1.2%)	g	100	100	100
	s	100	100	100
	f	81	89	76
	v	6	18	10
	g	100	100	100
	s	50	0	100
	f	90	87	75
	v	11	0	5
	g	99	97	100
	s	100	100	100
	f	68	73	63
	v	4	4	3
	g	100	100	100

Data in parentheses are prevalence of food hypersensitivity.

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories;
H-S = Hollister-Stier Laboratories; s = sensitivity; f = specificity; v = positive predictive accuracy; g = negative predictive accuracy.

*Mean wheal diameter ≥ 3 mm; not all patients were tested to all antigens.

Sensitivity and specificity are statistical measures of how well a diagnostic test correctly identifies confirmed cases of disease. On the other hand, predictive accuracies indicate how likely an individual is to have a disorder given the result of the diagnostic test. Be-

TABLE V. Descriptive value of skin prick tests; ratio of allergen:histamine mean wheal diameter >1

Antigen	Parameter	ALO	Gr	H-S
Egg (50%)	s	83	88	93
	f	66	69	60
	v	71	74	69
	g	79	85	89
Egg white	s	89	89	—
	f	66	65	—
	v	89	65	—
	g	87	85	—
Peanut (31%)	s	96	96	96
	f	77	60	48
	v	67	51	44
	g	97	97	96
Milk (13%)	s	64	100	91
	f	78	78	78
	v	30	42	39
	g	94	100	98
Fish (15%)	s	100	100	100
	f	60	77	69
	v	31	42	35
	g	100	100	100
Soy (7%)	s	67	100	83
	f	77	62	53
	v	18	16	12
	g	97	100	98
Wheat (2.3%)	s	100	100	100
	f	73	84	64
	v	8	13	7
	g	100	100	100
Beef (2.1%)	s	100	100	100
	f	73	82	63
	v	5	12	6
	g	100	100	100
Chicken (2.1%)	s	100	0	100
	f	81	74	58
	v	12	0	0
	g	97	100	100
Pork (1.2%)	s	100	100	100
	f	58	39	53
	v	3	2	3
	g	100	100	100

Data in parentheses are prevalence of food hypersensitivity.

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories; H-S = Hollister-Stier Laboratories; s = sensitivity; f = specificity; v = positive predictive accuracy; g = negative predictive accuracy.

cause predictive accuracies are highly dependent on the prevalence of the disorder in the population under study, the prevalence of hypersensitivity to each food in the study patients is given. In general, the higher the prevalence of a specific food hypersensitivity in the study group, the better the positive predictive accuracy will appear.¹² Conversely, the lower the prevalence, the better the negative predictive accuracy will

appear. As seen in Table IV, positive predictive accuracies for the individual commercial extracts varied widely, ranging from 0% for Greer Laboratories' chicken extract to 79% for Allergy Labs of Ohio's whole-egg extract. Negative predictive accuracies were generally very good, from 85% for Greer Laboratories' egg white extract to 100% for several extracts.

With the use of McNemar's test to compare, how

TABLE VI. Skin prick tests with mean wheal diameter ≥ 3 mm of the negative control that lacked any flare (erythema) response

Antigen	ALO	Gr	H-S
Egg	8/47 (17%)	6/49 (12%)	6/50 (12%)
Milk	6/20 (30%)	4/18 (22%)	7/22 (32%)
Wheat	5/13 (38%)	2/13 (15%)	7/22 (32%)
Peanut	6/29 (21%)	3/38 (8%)	8/38 (21%)

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories; H-S = Hollister-Stier Laboratories.

well skin prick test result for each company's extracts correctly predicted results of the DBPCFCs, there were no differences in predictive values for the whole-egg, egg white, or peanut reagents. The predictive value of Allergy Labs of Ohio's soy extract was significantly better than the soy preparations from both Greer Laboratories and Hollister-Stier ($p < 0.01$). Allergy Labs of Ohio's extracts for chicken and wheat were also significantly better predictors than Hollister-Stier's extracts for these foods. The predictive value of the Allergy Labs of Ohio and Greer Laboratories extracts differed significantly only for soy, whereas the predictive value of Greer Laboratories reagents were also significantly better than values for Hollister-Stier's milk, fish, and beef.

Several European investigators have emphasized the need to standardize skin prick test techniques.¹³⁻¹⁵ The Scandinavian Society of Allergology has recommended the use of histamine as a reference substance (for allergen:histamine ratios, or HEP unit) to minimize the influence of differences in skin test techniques between clinics. Based on a consideration of a skin prick test as positive only when the allergen:histamine ratio is ≥ 1 , Table V lists the sensitivity, specificity, and predictive accuracies of each reagent. The predictive value of the allergen:histamine ratio was not significantly different than predictive values derived from measurement of mean wheal diameters in this group of patients. However, all tests were performed and quantitated by one individual in this study. If skin tests had been applied by several technicians, use of the allergen:histamine ratio (HEP unit) may have proved superior.

DISCUSSION

The diagnosis of food hypersensitivity involves acquisition of a careful history, physical examination, in vivo or in vitro diagnostic tests, institution of elimination diets, and confirmation by blinded oral food challenge. Direct skin testing with commercially available food allergen extracts has been shown to be a useful diagnostic procedure for screening potential IgE-mediated hypersensitivity reactions.^{1-6, 16-19} Skin

tests may be administered by the epicutaneous or intracutaneous routes. However, Bock et al.^{16, 18} demonstrated that intradermal skin tests with food allergens had no positive diagnostic advantage over puncture (or prick) skin tests. It was concluded that the increased sensitivity of intradermal skin tests would lead to even larger numbers of clinically irrelevant (or FP) skin tests than seen with the prick technique.

The literature provides conflicting viewpoints on the best means of measuring and interpreting allergy skin test results. Some investigators have found the mean diameter of the flare to be most reproducible,^{8, 20, 21} whereas others have found the mean wheal diameter to be less variable.^{13, 22} Although the mean diameter of erythema (flare) was measured, it was found to be more variable than the wheal diameter for all reagents and, as previously demonstrated,^{2, 13, 22} a poor predictor of clinical hypersensitivity. This overall variability of the flare occurred primarily because many of the patients had large wheals with no evident erythema (Table VI). Depending on the commercial extract used, positive wheal responses were present 8% to 38% of the time with no evidence of erythema. The frequent absence of erythema may be unique to patients with atopic dermatitis or to skin tests performed with food allergens.

There are approximately 12 companies that market skin test reagents in the United States. Reagents from three firms—Allergy Labs of Ohio, Greer Laboratories, and Hollister-Stier—were selected for comparisons of their ability to predict accurately the presence or absence of clinical food hypersensitivity. Skin tests were applied by the prick technique and the mean diameter of the wheal and erythema reactions were recorded. The back was chosen as the test site for several reasons: (1) it avoids differences in wheal size characteristically found between the right and left arms,¹³ (2) it provides a large reactive surface on which to carry out multiple skin tests, and most importantly, (3) it is one of the most constant uninvolved skin areas in patients with atopic dermatitis.

Appropriately performed, results of skin prick tests have been shown to be highly reproducible.^{13, 14, 23}

TABLE VII. Predictive efficiency indices of commercial food allergen extracts from three commercial sources

Reagent	ALO (%)	Gr (%)	H-S (%)
Egg	86	85	88
Egg white	87	81	—
Peanut	87	84	80
Milk	77	85	78
Fish	83	85	79
Soy	72	71	72
Wheat	72	71	72
Beef	69	73	70
Chicken	70	65	68
Pork	68	68	68

ALO = Allergy Laboratories of Ohio; Gr = Greer Laboratories; H-S = Hollister-Stier Laboratories.

However, the lack of standardization and validation of commercial reagents may lead to considerable variability in the predictive value of various products.^{24, 25} Comparisons between the different commercial food extracts evaluated in this study must be interpreted with caution, because only one lot of reagents from each company was tested. Different lots of antigen extract from the same company have been found to vary in potency by up to a hundredfold.^{26, 27} Consequently, several lots of extracts from each company would have to be tested before general comparisons could be made. In addition, the inpatient coefficient of variation of eight skin prick tests to histamine in eight subjects was 10.1%. The inpatient coefficient of variation for the various food antigens tested would be expected to be of this order; thus small differences between skin test results would not be significant.

Although considerable inpatient variability in wheal size was elicited with the food extracts from the three commercial sources, similar to that reported by Imber²⁴ with pollen extracts, the median wheal sizes for the groups were quite similar, except for Greer Laboratories' peanut extract (Table III). In addition, utilizing the criteria first established by May²² that positive skin test wheals must be ≥ 3 mm of the negative control, much of the variability in the mean wheal diameters translated into minimal differences in the predictive value of the test.

It has been shown⁶ that skin prick test results are excellent negative indicators of immediate food hypersensitivity, whereas their positive predictive value is marginal. Because the McNemar statistic can only reflect significant differences, a predictive efficiency index was formulated for each food extract to reflect its clinical value as a skin test reagent. This was calculated by the formula: Predictive efficiency in-

dex = $(v + 2g)/3 \times 100\%$, where v is the positive predictive accuracy and g is the negative predictive accuracy. It was assumed that the clinical consequence of an FN skin test was potentially more dangerous to the patient than an FP test. Therefore, the negative predictive accuracy was weighted by multiplying it by two to reflect this assumption. Table VII lists the predictive efficiency index for each reagent. Indices ranged from 70% to 88% for this patient group. Based on these indices, the milk extract from Greer Laboratories appeared slightly better and the fish extract from Hollister-Stier slightly inferior to respective reagents from the other companies for the lots tested.

Although the negative skin prick test result provides a very good means of excluding IgE-mediated food hypersensitivity, it is not perfect. Of the 102 food hypersensitivities diagnosed by DBPCFC or "convincing" history of anaphylaxis, several were not detected by prick skin testing with certain commercial reagents based on the criteria for positive test results established (Allergy Labs of Ohio, egg [4], peanut [2], milk [3], soy [3], chicken [1], total [12]; Greer Laboratories, egg [4], peanut [1], milk [1], soy [1], chicken [2], total [9]; and Hollister-Stier, egg [2], peanut [2], milk [2], total [6]). Most of these skin test results that were interpreted as negative did have erythema and a wheal < 3 mm at the skin test site. Although having a larger number of FP skin test results, the Hollister-Stier reagents were the least likely to miss symptomatic food hypersensitivity in this population.

Two major issues must be considered in using the predictive values of skin prick test results generated in this study group when making generalizations about their value in other populations. First, the predictive value of a test is dependent on the prevalence of the disorder in a population.¹² Because the prevalence of

food hypersensitivity in this population was very high, it is expected that the positive predictive accuracy will look significantly better and the negative predictive accuracy significantly worse than corresponding values derived in a population in which food hypersensitivity is much less frequent. This can be appreciated by recalling the formulas for positive (v) and negative (g) predictive accuracies:

$$v = \frac{sP}{sP + (1 - f)(1 - P)}$$
$$g = \frac{f(1 - P)}{f(1 - P) + (1 - s)P}$$

where *s* is the sensitivity, *f* is the specificity, and *p* is the prevalence. For example, in a population in which the prevalence is 50%, Greer Laboratories' egg extract had a positive predictive accuracy of 78% and a negative predictive accuracy of 89%. If the same skin test reagents were used in a population in which the prevalence of egg hypersensitivity was 2%, it can be calculated from the formulas that the positive predictive accuracy is 8% and the negative predictive accuracy is 99.7%. In other words, skin prick tests would continue to be an excellent means of excluding immediate (IgE-mediated) food hypersensitivity but would be even less useful as a positive indicator of clinical hypersensitivity.

The second major question is whether data generated in food-sensitive children with atopic dermatitis can be extrapolated to food-sensitive subjects with other atopic disorders. Based on findings of Bock et al.¹⁸ in children with severe asthma, values for the sensitivity (*s*) and specificity (*f*) can be calculated for egg (*s* = 1.00 and *f* = 0.86) in a population where the prevalence is 13.2%. Extrapolating to a population in which egg hypersensitivity is 2%, as done above, the positive predictive accuracy is 5% and the negative predictive accuracy is 100%. These values are very similar to the results of calculations obtained from the patients with atopic dermatitis. Similar findings are seen with the peanut, milk, and soy extracts. This would suggest that predictive indices determined for food extracts in this study are similar to those in patients with food hypersensitivity and primarily respiratory symptoms. Children in both this study (patients selected for atopic dermatitis) and the study of Bock et al.¹⁸ (patients selected primarily for respiratory allergy) experienced multiple-system allergic reactions (cutaneous, gastrointestinal, and respiratory). Therefore, these studies should provide useful information regarding skin testing in the study of other pediatric populations being evaluated for IgE-mediated food hypersensitivity.

Variability in the predictive value of skin test extracts to foods from three well-regarded commercial sources were found. Differences in production procedures (starting material, methods of extraction, storage²⁸) could easily account for these differences. For the conditions under which the lots were tested, two companies' reagents gave slightly better results. However, when lot-to-lot variability and inpatient variability are accounted for, these differences probably are of little clinical significance. Food extracts from each company provide useful information for the diagnosis of symptomatic food hypersensitivity. As shown previously,⁶ negative skin prick tests are an excellent (but not perfect) means of excluding IgE-mediated food hypersensitivity. The usefulness of positive skin prick test results, on the other hand, will depend on the population under study and the particular food antigen being evaluated. In general, a positive skin prick test result merely suggests the presence of symptomatic food hypersensitivity. Such a result should be considered confirmatory in the case of an obvious allergic reaction occurring shortly after the isolated ingestion of a common food allergen or as a guide for undertaking a more definitive, blinded oral food challenge procedure.

It is also apparent from this study that better standardized and validated skin test reagents for all foods are needed. Several studies suggest that commercial extracts to many fruits (apple, orange, watermelon) and vegetables (celery, carrot, tomato) may lack the relevant allergens for detecting hypersensitivity in many patients.²⁹⁻³⁴

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