

# Evaluating the Clinical Relevance of Food Sensitivity Tests: A Single-Subject Experiment

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## Abstract

A number of tests are available to identify food sensitivities. This article presents an analysis of the diagnostic value of nine different food sensitivity tests run concurrently on a healthy 33-year-old female with a previous diagnosis of environmental allergies. This case study evaluated conventional allergy tests (skin prick and serum IgE), tests of other immune-mediated reactions (serum IgG and salivary IgA), and tests that claim to measure the energetic reaction of the whole person to particular foods (kinesiology, Vega, and Carroll testing). The results of an elimination/challenge test were used as indicators of true food reactions in order to calculate the sensitivity, specificity, and positive predictive value (PPV) of each test. In a separate evaluation, the variability of results across the four tests measuring IgG was determined. Results show several tests (one of the two serum tests of IgG alone, both serum tests of IgE and IgG, skin prick testing, and Carroll testing) may have very high (100%) specificity and PPV when test results are compared to the results of an elimination/challenge test. Sensitivity, however, is low across tests (50-60 percent), likely because different tests measure different mechanisms of food reactions and because food sensitivities can be the result of a number of different mechanisms. Very little consistency was found among the results of the four tests measuring IgG – 79-83 percent disagreement. This study shows a number of tests may be

useful in identifying foods to which a patient is reactive; however, no one test is likely to identify all reactive foods.

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## Introduction

This article presents the results of a set of nine different food sensitivity tests run concurrently on a healthy 33-year-old female with a previous diagnosis of environmental allergies. This “subject” (one of the authors) underwent the series of tests to identify foods to which she was sensitive and to determine the diagnostic value of the various types of tests available. This paper presents the results of the latter.

In this case analysis, the term “food sensitivity” includes all types of adverse reactions to food. In general, adverse food reactions can be divided into two groups: (1) those proven to be immunological in nature and thus are hypersensitivity reactions – mostly IgE-mediated (food allergies); and (2) those not proven to be immunologic in nature (food intolerances).<sup>1</sup>

While the actual prevalence of adverse food reactions is unknown, a consumer survey has indicated one-third of American households believe that at least one family member has adverse

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food reactions.<sup>1</sup> Estimates of the prevalence of food allergies range from 1-2 percent of the adult population to 4-8 percent of the pediatric population.<sup>1,2</sup> Prevalence estimates of one common type of food intolerance, lactose intolerance, range from two percent for those of Northern European descent to nearly 100 percent in adult Asians and Native Americans.<sup>3</sup>

There are a number of diagnostic tests available to identify food sensitivities. The “gold standard” for diagnosis of food sensitivity is the double-blind, placebo-controlled, oral food challenge. It is simple, but time consuming, and is usually administered only after other tests have indicated suspect foods. Conventional allergists focus on the immune system’s response to a food or other allergen through IgE-mediated hypersensitivity reactions. These practitioners tend to use either skin or serum tests.<sup>1</sup> In the skin prick test, a minute quantity of a suspected allergen is injected into the epidermis. Significant erythema or a wheal and erythema indicate a positive reaction. Serum tests include those using radioallergosorbent test (RAST) or enzyme-linked immunosorbent assay (ELISA) techniques. A high level of circulating IgE specific to a particular food or other allergen indicates a positive result.

A number of serum tests are available that measure circulating IgG specific to particular foods or other antigens. These tests also measure an immune system response, but the IgG response to foods is not as well understood.<sup>1</sup> Similarly, salivary tests of secretory IgA specific to particular allergens are available. Again, the secretory IgA response to specific foods is not well understood.<sup>4</sup>

Other diagnostic tests look at non-immune-mediated reactions to food. These approaches are not generally recognized by conventional medicine and are believed to measure the energetic reaction of the whole person to a particular food. Included in this category are kinesiology (which uses loss in muscle strength as an indicator of food sensitivity), Vega testing (which uses a machine to measure electromagnetic pulses through the body), and Carroll testing (which measures intolerance to a food by running an electric current through a small sample of the subject’s blood).

The purpose of this case analysis is to evaluate the diagnostic value of nine different food sensitivity tests, including commonly used conventional allergy tests, as well as other immune-mediated reaction tests and tests that measure the reaction of the whole person to particular foods.

## Methods

The tests chosen for this study were from among those known and available to the naturopathic physician community in the Seattle, Washington area. No attempt was made to be exhaustive, nor completely representative of the full breadth of the tests available. Each of the laboratories and testers donated time and materials. The four blood draws, the blood sample, and the saliva sample were taken on the same day. The other tests – kinesiology, Vega testing, and skin prick – were performed the following two days. Once the results were received from all tests, a copy of the full set of results was sent to each of the participating testers and laboratories. Each was allowed to comment on the results seen, and their comments have been incorporated into this paper where appropriate.

In order to establish a baseline of actual food sensitivities by which to evaluate these various tests, the foods found reactive were subjected to an elimination/challenge test. It would have been ideal to perform a double-blind, placebo-controlled, oral food challenge for each reactive food. However, time and budget constraints (to purchase the freeze-dried, encapsulated, or liquid forms of the reactive foods needed for proper blinding) made a more pragmatic approach necessary.

Also due to time constraints, the subject performed the elimination/challenge three months after the tests were performed. The subject eliminated from her diet for a period of two weeks all foods shown to be reactive (i.e., those recommended to be eliminated from the diet) according to any of the tests. The only foods the subject ate during this period were those evaluated by at least one test and found to be non-reactive by all tests performed. The subject then introduced one challenge food at a time. The foods were eaten at three consecutive meals, symptoms recorded, and then that food was removed from the diet again. Three days later the next food was challenged.

*Table 1. Characteristics of the Tests Used*

Laboratory or Test	Testing technique	Number of foods tested
Lab A	IgG ELISA (serum)	115 foods, spices, beverages, sweeteners
Lab B	IgG1 & 4 ELISA (serum)	90 foods, spices, beverages, other
Lab C	IgG & IgE ELISA (serum)	89 foods, beverages, sweeteners, other
Lab D	IgG4 & IgE ELISA (serum)	190 foods, spices, beverages, sweeteners, other
Lab E	sIgA ELISA (saliva)	4 food proteins
Skin prick	Skin prick test	40 foods, beverages
Kinesiology	Kinesiology (muscle strength testing)	147 foods, spices, beverages, sweeteners, other
Vega testing	Vega machine (measures electromagnetic pulses through the body)	229 foods, spices, beverages, sweeteners, other
Carroll testing	Carroll testing machine (measures enzyme defects or deficiencies via a blood sample placed in an electric current)	8 food groups and 6 combinations of those foods

ELISA = enzyme-linked immunosorbent assay. The "other" category of substances tested varied by test, but could include mold, drugs, and food additives.

Due to the impossibility of performing a rigorous challenge on the full set of foods found to be reactive, the authors chose a subset of foods to challenge. The challenge foods were chosen where possible to represent individual tests. That is, an ideal challenge food to represent a particular test would be one evaluated according to a number of tests, but only found to be reactive according to that one test. In total, eight foods were challenged over a period of 24 days.

Since some tests evaluated categories of food (e.g., cheeses) and others included evaluation of individual food components (e.g., gliadin, a component of wheat), an algorithm was developed to allow comparison of results across tests. When a test measured sensitivity for a category of foods (e.g., cheese), it was assumed the result for that category also applied to all types of foods included in that category (e.g., cottage cheese and American cheese). That is, for the purposes of comparison across tests, the test that evaluated

“cheese” would also be assumed to have evaluated cottage cheese and American cheese and found the same sensitivity in these specific foods as it did in the food category. Similarly, sensitivity to one component of a food (e.g., gliadin) is assumed to also mean sensitivity to the whole food (e.g., wheat). However, the results for one type of a food (e.g., cheddar cheese) were not assumed to apply to another type (e.g., Swiss cheese) – sensitivity to the whole food did not equal sensitivity to individual components. A person could react to wheat because of a sensitivity to a different component of wheat than gliadin, and sensitivity to one component of a food (e.g., gliadin) was not assumed to also mean sensitivity to another component (e.g., wheat bran).

The results of the challenges were used as indicators of true food reactions for a calculation of the sensitivity, specificity, and positive predictive value (PPV) of each test. The sensitivity of a test is calculated as the proportion of challenge foods that produced a reaction (true positives plus false negatives) that the test identified as a reactive food (true positives). The specificity of a test is calculated as the proportion of challenge foods that produced no reaction (true negatives plus false positives) that the test identified as a non-reactive food (true negatives). Sensitivity and specificity are measures of the accuracy of a test. PPV is a measure of the validity of a test. The PPV was calculated as the proportion of positive test results validated with a positive food challenge.<sup>5</sup> Only those challenge foods evaluated by a test were used in the calculations for that test. In a separate evaluation, the variability of results across the four tests measuring IgG was determined.

Table 1 shows the list of tests performed for this study, including the testing technique used and the number and types of foods tested. The “other” substances varied by test and included such things as drugs, food additives, and mold. For the remainder of this article the term “food” will be used for all substances tested.

## Subject

The subject was a 33-year-old female with a previous diagnosis of allergic rhinitis in response to environmental allergens. The diagnosis was made in 1989 by an allergist using a skin test. Medications given at that time were discontinued by the patient after 1991. The subject also had a history of elevated eosinophils and a significantly elevated anti-nuclear antibody (ANA) titer, later found to be anti-centromere. Subsequent workup by a rheumatologist revealed no obvious manifestation of autoimmune disease. The subject’s only other diagnoses included a herniated disc (L5-S1), uterine fibroids, and infertility. The subject was on no prescription or over-the-counter medications at the time of testing or for the 10 months prior.

The subject purposely ate a variety of foods for the two weeks prior to testing. The subject also discontinued all supplements for the testing days and the five days prior to testing. Symptoms of the subject at the time of testing:

### ▶▶ Intermittent symptoms:

- ▶▶ Acne
- ▶▶ Bloating
- ▶▶ Scalp rash
- ▶▶ Malar rash

### ▶▶ Seasonal symptoms:

- ▶▶ Itchy throat
- ▶▶ Post-nasal drip
- ▶▶ Nasal congestion
- ▶▶ Weight gain

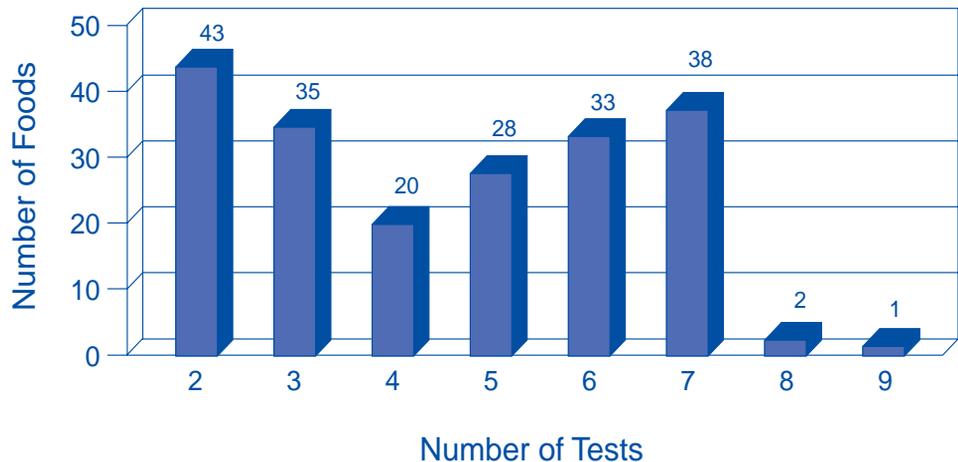
## Results

Across all nine tests, a total of 294 foods, spices, beverages, sweeteners, or other substances were tested. Approximately one-third of foods (94 of 294) were evaluated by only one test. Figure 1 shows the number of foods tested by more than one test. Only one food was evaluated by all nine tests (eggs) and only two foods were evaluated by eight tests (wheat and soybean).

Of the 294 foods tested, just over 50 percent (156) were considered reactive (i.e., were recommended to be eliminated from the diet) according to one or more tests. Almost two-thirds of these were shown to be reactive by only one test. The numbers of foods found to be reactive by more than one test are shown in Figure 2. Only one food was shown to be reactive by six tests (egg), two foods were shown to be reactive by five tests (egg white and wheat), and three foods were shown to be reactive according to four tests (egg yolk, bean, and pinto bean). The number of foods tested and the number found reactive by each test are shown in the lower-middle portion of Table 2. The 156 reactive foods were eliminated from the subject's diet for two weeks. During this period the subject lost 16 pounds and all other symptoms cleared.

Table 2 shows the foods chosen for the challenge component of the elimination/challenge test in the order challenged. Only three tests had foods that met the original criteria for an "ideal" challenge food – a food evaluated by a number of tests, but only found reactive according to one test – Lab C (coconut), Vega testing (orange), and kinesiology (pork). All other tests identified reactive foods that were also found to be reactive according to one or more other tests. The remaining challenge foods were chosen either because they were the

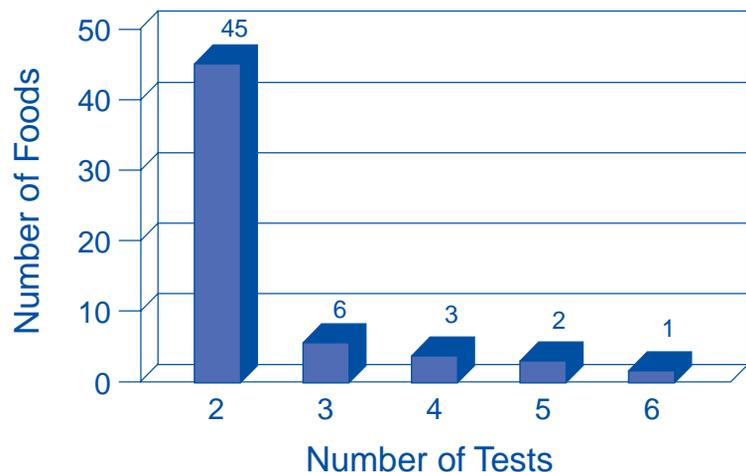
*Figure 1. Number of Foods Evaluated by More than One Test*



only food found to be reactive by a particular test, or because they were found to be highly reactive by one or more tests.

The lower portion of Table 2 shows two foods that produced symptoms during the elimination phase of the elimination/challenge test.

*Figure 2. Number of Foods Found Reactive by More than One Test*



*Table 2. Challenge Schedule and Numbers of Tested and Reactive Foods by Test*

	Lab A	Lab B	Lab C	Lab D	Lab E	Skin Prick	Kinesiology	Vega	Carroll
Immunoglobulin measured	IgG	IgG1 & IgG4	IgG & IgE	IgG4 & IgE	sIgA	IgE			
Reactive criteria	≥ 1	≥ 2	≥ 1	Sig	Pos	≥ 2	Pos	Pos	Pos
Pork	0	0	0	0		0	Pos	Neg	Neg
Coconut	0	0	1	Insig			Neg	Neg	Neg
Banana	1	0	VL	Insig		3	Neg	Neg	Neg
Soybean	0	0	0	0	Pos	0	Pos	Neg	
Orange	0	0	0	0		0	Neg	Pos	Neg
Wheat	1	3	0	Insig	Neg	4	Pos	Pos	Neg
Egg	2	5	VL	Sig	Neg	0	Pos	Pos	Pos
Yeast, Brewer's	3	0	VL	Insig			Pos	Neg	
# Foods tested	115	90	89	190	4	40	147	229	14*
# Reactive foods	12	3	4	1	1	10	90	69	2*
Unexpected Food Reactions During Elimination Phase									
Shrimp	0	0	0	0		0			
Lemon	0	0	0	0		0	0	0	0

Blank cells indicate that food was not evaluated by that test.

The shaded boxes indicate that food to be reactive according to that test.

Sig=Significant; Insig=Insignificant; Pos=Positive; Neg=Negative; VL=Very Low; 0=No reaction

\*Tested 8 food groups and 6 combinations and found one food (eggs) and one combination (fruit and sugar) to be reactive.

As can be seen, these foods were not shown to be reactive according to any of the tests. The symptoms experienced are shown at the bottom of Table 3. Once symptoms were experienced, these foods were removed from the diet. Table 3 shows the symptoms observed for each of the foods challenged, and for the two foods found to be reactive during the elimination phase of the diet.

Table 4 shows the results of the sensitivity and specificity calculations for each test. Two sets of sensitivity results were calculated: one including and one excluding the two foods found to

be reactive during the elimination phase. Five of nine tests show 100-percent specificity, indicating a zero false-positive rate. These are Labs B, C, and D, skin prick testing, and Carroll testing. If there was no reaction to the food on challenge, these tests were also negative for food reaction. However, none of the tests was highly sensitive. To be highly sensitive a test would have to have a low false-negative rate. In this study, even if the challenge demonstrated a reaction to a food, the tests often failed to indicate the food was reactive. The PPV was high (100%) for the same tests

*Table 3. Foods Challenged and Reactions Observed (shown in the order challenged)*

Food Challenged	Reaction Observed
Pork	Nasal discharge, malar rash, headache
Coconut	Nausea, mouth itch
Banana	Phlegm, headache, stomach ache, cough, sneeze, mouth itch
Soybean	No reaction
Orange	No reaction
Wheat	Phlegm, bloating, dermatome pain, scalp rash
Egg	Stomach ache, nausea, belching, post-nasal drip, cough, mouth itch
Brewer's Yeast	No reaction
Reactions to Foods During Elimination Phase Only	
Shrimp	Malar rash
Lemon	Scaly rash

*Table 4. Sensitivity, Specificity, and Positive Predictive Value (PPV) of Each Test*

	Lab A	Lab B	Lab C	Lab D	Lab E	Skin Prick	Kinesiology	Vega	Carroll
Immunoglobulin measured	IgG	IgG1 & IgG4	IgG & IgE	IgG4 & IgE	sIgA	IgE			
Sensitivity: Excluding unexpected foods*	60%	40%	20%	20%	0%	50%	60%	40%	20%
Sensitivity: Including unexpected foods*	43%	29%	14%	14%	0%	33%	50%	33%	17%
Specificity	67%	100%	100%	100%	0%	100%	33%	67%	100%
Positive predictive value	75%	100%	100%	100%	0%	100%	60%	67%	100%

\*Excluding or including the two foods (shrimp and lemon) found to be reactive during the elimination phase. Sensitivity=TP/(TP+FN); Specificity=TN/(TN+FP); Positive predictive value=TP/(TP+FP); TP=true positives; TN=true negatives; FP=false positives; FN=false negatives

**Table 5.** *The Mechanism of Adverse Food Reaction Measured by the Food Sensitivity Tests Used in this Study*

Type of Test	Mechanism of Food Sensitivity Detected
IgE ELISA (Serum)	Type I immediate hypersensitivity reaction and late-phase reaction
IgG (IgG1 & IgG4) ELISA (Serum)	Type III immune-complex delayed hypersensitivity reaction
Skin Prick IgE	Type I immediate hypersensitivity reaction and late-phase reaction
sIgA ELISA (Saliva)	Mechanism unclear
Kinesiology	All mechanisms
Vega testing	All mechanisms
Carroll testing	Food "intolerance" – i.e., improper metabolism of a food or combination of foods due to enzyme defects or deficiencies

showing a high specificity.\* This indicates that for these tests, if the test result for a particular food is positive (i.e., the food is reactive), the results of the challenge for that food will also be positive.

Looking at the four tests measuring IgG (Labs A through D), there were 65 foods measured by all four tests. Of these, none were shown as reactive by all four tests, and 12 were shown as non-reactive by all four tests. This indicates an 82-percent probability of disagreement among these four tests. Looking at the two tests measuring only IgG (Labs A and B), there was a 79-percent probability of disagreement between the tests across 78 foods tested by both (two foods shown as reactive and 14 shown as non-reactive by both tests). For the two tests measuring both IgE and IgG (Labs C and D), there was an 83-percent probability of disagreement between the tests across 103 foods tested by both (two foods shown as reactive and 16 shown as non-reactive by both tests).

\* If false positives are zero, PPV and specificity will always both be 100%.

## Discussion

This article presents the results of a single-subject evaluation of the diagnostic value of a number of different tests of food sensitivity. According to this case evaluation, a number of tests (five of nine) show extremely high specificity and PPV (zero false-positives), but none have a high sensitivity (low false-negatives). The highest sensitivities were 50 or 60 percent, depending on whether the foods found to be reactive during the elimination phase were included in the calculations. This result is not surprising since food sensitivities can be the result of a number of different underlying mechanisms.

As discussed in the introduction, this report uses the term "food sensitivity" to include all types of adverse reactions to food. The term "food allergy" refers specifically to an immunological reaction involving IgE antibodies (i.e., Type I immediate hypersensitivity reaction and late-phase reaction).<sup>1,2,6</sup> In addition to food allergies, there can also be other delayed

hypersensitivity reactions mediated by the immune system via IgG (i.e., Type III immune-complex hypersensitivity reaction) and via immune cells (i.e., Type IV cell-mediated hypersensitivity reaction).<sup>6</sup> Even though most of the literature focuses on immunologically-mediated mechanisms, especially that of food allergy (IgE), it is likely that the majority of food reactions involve other mechanisms.<sup>7</sup> These mechanisms include:

- ▶▶ Hypoglycemic reactions, especially to sugars and other refined carbohydrates<sup>8</sup>
- ▶▶ Non-IgE histamine release sometimes called pseudo-allergic reactions, such as to food additives<sup>9</sup> such as tartrazine<sup>10</sup>
- ▶▶ Enzyme deficiencies such as are found in lactose intolerance,<sup>3</sup> fructose intolerance,<sup>11</sup> and sensitivity to dietary amines (deficiency of diamine oxidase)<sup>12,13</sup>
- ▶▶ Inappropriate binding of dietary lectins to cell walls or extracellular molecules, such as wheat lectins binding to deficient IgG in rheumatoid arthritis<sup>14</sup>
- ▶▶ Neurotoxic molecules, such as glutamate<sup>15</sup>
- ▶▶ Pharmacological actions, such as from salicylate-rich food<sup>16,17</sup>
- ▶▶ As yet unexplained mechanisms

Many food sensitivity-testing methods examine only one or two types of adverse food reaction mechanisms. The types of food sensitivities measured by the tests used in this study are shown in Table 5.

Given that the different tests are designed to detect different types of food sensitivities or reactions, it is not surprising the tests would have a much lower sensitivity than specificity. It is possible the tests with high specificity are accurate in their ability to detect a food reaction of the type they are designed to measure, but simply miss

other types of food reactions. These tests may actually have high sensitivity in patients who are only suffering from the type of food reaction they measure. However, this subject (and many others) may be reactive to foods through more than one mechanism, making any test that measures only one or two mechanisms less sensitive.

Given that Labs A through D all measured IgG, more consistency was expected across these four tests, especially between Labs A and B (both measured only IgG) and between Labs C and D (both measured IgG and IgE). Very little consistency was found between the results of these tests, however, with 79-83 percent disagreement. There are possible explanations for this level of variation among the tests. First, each of the tests measured a different combination of total IgG, IgG1, IgG4, and IgE. Second, each of the testing laboratories may be evaluating reactivity against antigens from different sources. Responses to inquiries via electronic mail from three of the four laboratories indicated different companies from which they purchased antigens.<sup>18-20</sup>

It is interesting that the saliva test for secretory IgA (sIgA) had no (0%) sensitivity, specificity, or PPV in our experiment. sIgA accounts for 60-70 percent of the body's total output of antibodies,<sup>6</sup> being the main antibody of the mucosal immune system and present in saliva, mucus, and breast milk. Salivary sIgA specific to cow's milk protein has been shown to predict an atopic disposition in infants.<sup>4</sup> However, the mechanism involved has not been described, and the authors could not find any other studies on sIgA specific to other food antigens. It is more common to measure total sIgA than sIgA specific to an antigen. Selective IgA deficiency is the most common primary immunodeficiency known and results in an increased incidence of allergy and intestinal malabsorption.<sup>6,21</sup> It is also known that total sIgA decreases in response to stress.<sup>22</sup>

There are a number of limitations to this comparison of food sensitivity tests. While it is unclear whether there would be any association with food sensitivities, it should be noted that the subject concurrently was diagnosed with heavy metal toxicity and had been following an intensive

detoxification protocol to remove those toxins. This protocol was initiated during the three months between the tests and the initiation of the elimination/challenge. This protocol, as well as the passage of time, could have changed the reactivity of foods from that shown on the tests. However, certain types of reactions are believed to be life-long – e.g., lactose intolerance, gluten intolerance, and Type I hypersensitivity reactions.<sup>21</sup>

This evaluation was conducted on only one subject; only one sample of serum, blood, or saliva was submitted to each testing laboratory or tester; and the individual testers performed tests only once. However, single-subject experiments have been recognized as useful research tools, even though most of their use has been in the area of the evaluation of therapies.<sup>23</sup> Finally, only a subset of the foods evaluated and found to be reactive were challenged. Selection of a different set of challenge foods may have significantly changed the results of this study.

This paper presents the results of a single-subject experiment comparing the results, accuracy, and validity of nine different tests of food sensitivity. The results show several tests (one of the two serum tests of IgG, both serum tests of IgE and IgG, skin prick testing, and Carroll testing) may have very high (100%) specificity and positive predictive value when test results are compared to the results of an elimination/challenge test. Sensitivity, however, is low across tests (50-60%, at best). This is likely due to the fact that different tests measure different mechanisms of food reactions and food sensitivities can occur via a number of different mechanisms. While a number of tests may be useful in identifying certain foods to which a patient is reactive, no one test is likely to identify all reactive foods.

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