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Original Research

Perception of Dietary Food Items as Food Allergens in Asthmatic Individuals in North Indian Population

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Key words: asthma, food allergens, perception, atopy

Background and Objective: The role of food allergy in asthma is well recognized but is poorly quantified. The aim of the present study was to document perceived food items as allergens and to determine their association with age, sex, socioeconomic status (SES), family history of asthma, smoking history, duration of illness, and total serum immunoglobulin (Ig)E.

Methods: A total of 261 clinically and spirometrically diagnosed patients with asthma were included in this study on an accrual basis. Of these, 237 patients thought that their asthma became aggravated after consumption of at least 1 food item. The perceived food item allergy and its association with age, sex, SES, family history of asthma, smoking history, duration of illness, and total serum IgE were assessed using a detailed, open-ended questionnaire.

Results: Food items were perceived as main allergens by 90% (237/261) of responders. Sixty-five percent (154/237) of patients who perceived at least 1 food item as an allergen had high total serum IgE levels. Of 22 suspected food items, 16 were significantly ($p < 0.05$) associated with at least 1 of the 6 study parameters.

Conclusion: Food items play a major role as food allergens on the basis of perception in asthmatic individuals. Some suspected food items are significantly associated with the demographic profile of asthmatic individuals.

INTRODUCTION

Bronchial asthma is characterized by chronic coughing, phlegm, shortening of breath, and wheezing [1]. It is estimated that ~300 million persons worldwide have asthma, approximately 50% of whom live in developing countries with limited access to essential drugs and treatment advice; therefore, asthma often is poorly controlled in these areas [2]. Furthermore, the prevalence of asthma has increased over the past decade in developed countries [3–5]. It is estimated that the cumulative prevalence rate ranges from 2.8% to 7.2% [6] and varies from country to country: 7% in France and Germany [7], 8% in the United States, and 15% to 18% in the United Kingdom [8]. In India, it is estimated that 15 to 20 million people are asthmatic [9]. Additionally, only an apparent increase in general prevalence can be seen in several

geographic areas, as well as in the numbers of difficult, refractory, and fatal (or near fatal) asthma cases [10].

Complex and confounding associations in the etiopathogenesis of asthma provide scope for additional studies. Studies have revealed that certain risk factors, such as age, smoking, and occupational exposure, are associated with an increased incidence of bronchial asthma [11]. The role of food allergy in asthma is well recognized but is poorly quantified. Food allergy and intolerance are common among small children, in whom eggs and milk are the 2 most commonly incriminated items [12,13].

Asthma and allergy are usually associated with early age at onset but may also affect elderly subjects, and diagnosis of these diseases is challenging because of coexisting disorders and underreporting of symptoms [14,15]. Approximately one third of children with food allergy have asthma and 4% to 8% of children with asthma have food allergy [16], but data are

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Table 1. Demographic Profile of the Sample Used for Analysis (Frequency and Percentage in Each Category) (N = 237)

Demographic Profile	n (%) / Mean $\pm$ SD
Gender	
Male	122 (51.5)
Female	115 (48.5)
Age, y (mean $\pm$ SD)	33.2 $\pm$ 6.6
Age group	
<10	17 (7.2)
20 Oct	49 (20.7)
20–30	60 (25.3)
>30	111 (46.8)
Socioeconomic status	
Upper	7 (3.0)
Upper middle	26 (11.0)
Lower middle	78 (32.3)
Upper lower	86 (36.3)
Lower	40 (16.9)
Smoking	
Never-smoker	200 (84.4)
Ex-smoker	28 (11.8)
Current smoker	9 (3.8)
Family History	
Yes	190 (80.2)
No	47 (19.8)
Duration	
1–5 y	26 (11.0)
5–10 y	59 (24.9)
10–15 y	74 (31.2)
15–20 y	44 (18.6)
20–25 y	23 (9.7)
>25 y	11 (4.6)
Serum IgE, KIU/L, mean $\pm$ SD	669.6 $\pm$ 421.6
Atopic	154 (65)
(mean $\pm$ SD)	544.7 $\pm$ 312.7
Nonatopic	83 (35)
(mean $\pm$ SD)	124.19 $\pm$ 24.3

insufficient regarding food allergy and asthma in adults. Certain food items that are of minor nutritional significance have been cited as the cause of immunoglobulin (Ig)E-mediated severe asthmatic response, for example, royal jelly [17] and fenugreek [18]. In addition, some specific food allergies have received particular prominence. Cow's milk is one of the common causes of allergic manifestations in childhood [19]. The prevalence of peanut and tree nut allergy in adolescents was comparably less than in young children with asthma [20]. The estimated point prevalence of allergy to egg was 1.6%, with an upper estimate of the cumulative incidence of 2.6% [21]. Thus, in seeking an explanation for the large worldwide variation in prevalence of food allergy in asthma, dietary food items are a potentially important area of study. This study was conducted to determine the perceived dietary food items responsible for aggravation of asthma in adults and their association with age, sex, socioeco-

nomics status (SES), family history of asthma, smoking, duration of illness, and total serum IgE.

MATERIALS AND METHODS

This study included our initial 261 clinically and spirometrically diagnosed subjects with bronchial asthma aged between 15 and 40 years. The diagnosis of asthma was confirmed on criteria laid down by the International Union against Tuberculosis and Lung Diseases (IUATLD) Asthma Questionnaire [22]. Patients were enrolled as they came on an accrual basis from August 2006 to September 2007 and were recruited from the outpatient department of the Department of Pulmonary Medicine, CSM Medical University and King George's Medical College Hospital, Lucknow, India. Informed consent after full explanation of the purpose of the study was obtained from all subjects, and the study was duly approved by the institutional ethical committee.

Patients having any associated illness, chronic obstructive pulmonary disease (COPD), pregnancy, physical or mental impairment, diabetes, or hypertension and those receiving treatment for any acute illness were excluded from the study. Those with a history of asthma of less than 1 year were also excluded.

A detailed questionnaire was designed. It was tested for face validity by 2 experts. Test-retest reliability was evaluated on 20 questionnaires with excellent correlation. The study started by

Table 2. Food Allergens Suspected in Asthmatic Patients (N = 261)

Suspected Food	No. of Subjects (%)
Curd*	214 (82.0)
Lemon*	208 (79.7)
Banana*	203 (77.8)
Urd/Horse bean*	202 (77.3)
Gram/Green gram*	192 (73.6)
Rice	191 (73.2)
Green pea*	189 (72.4)
Milk	186 (71.2)
Rajma/Red kidney beans*	179 (68.6)
Masoor/split red lentil*	177 (67.8)
Egg	175 (67.0)
Orange*	169 (64.8)
Radish*	168 (64.3)
Chicken*	166 (63.6)
Lobia/black-eyed beans	166 (63.6)
Groundnut*	160 (61.3)
Fish	158 (60.5)
Onion*	152 (58.2)
Soyabean*	150 (57.5)
Potato*	141 (54.0)
Arhar/Split red gram*	115 (44.0)
Moong/Split green gram	35 (13.5)
No food allergy	27 (10.4)

Table 3. Association between Suspected Food Items and Demographic Profile (Age, Sex, Socioeconomic Status, Smoking, and Family History and Duration) of Patients with Asthma

	Curd, N (%)	Masoor, N (%)	Soyabean, N (%)	Arhar, N (%)	Orange, N (%)	Radish, N (%)	Chicken, N (%)
Sex							
Male	103 (52.8)	92 (57.1)	70 (51.1)	65 (61.9)	70 (45.5)	70 (45.8)	68 (45.0)
Female	92 (47.2)	69 (42.9)	67 (48.9)	40 (38.1)	84 (54.5)	83 (54.2)	83 (55.0)
<i>p</i> value	0.372	0.011*	0.89	0.004*	0.012*	0.017*	0.009*
Age group							
<10	13 (6.7)	15 (9.3)	15 (10.9)	11 (10.5)	14 (9.1)	15 (9.8)	9 (6.0)
10–20	43 (22.1)	39 (24.2)	33 (24.1)	25 (23.8)	31 (20.1)	26 (17.0)	32 (21.2)
20–30	42 (21.5)	42 (26.1)	29 (21.2)	18 (17.1)	37 (24.0)	36 (23.5)	37 (24.5)
>30	97 (49.7)	65 (40.4)	60 (43.8)	51 (48.6)	72 (46.8)	76 (49.7)	73 (48.3)
<i>p</i> value	0.022*	0.012*	0.011*	0.031*	0.456	0.041	0.749
SES							
Upper	3 (1.5)	6 (3.7)	4 (2.9)	4 (3.8)	6 (3.9)	4 (2.6)	5 (3.3)
U middle	23 (11.8)	19 (11.8)	9 (6.6)	13 (12.4)	16 (10.4)	18 (11.8)	16 (10.6)
L middle	64 (32.8)	59 (36.6)	37 (27.0)	30 (28.6)	53 (34.4)	48 (31.4)	47 (31.1)
U lower	80 (41.0)	51 (31.7)	59 (43.1)	42 (40.0)	60 (39.0)	55 (35.9)	60 (39.7)
Lower	25 (12.8)	26 (16.1)	28 (20.4)	16 (15.2)	19 (12.3)	28 (18.3)	23 (15.2)
<i>p</i> value	0	0.161	0.003*	0.574	0.092	0.868	0.615
Smoking							
Never	166 (85.1)	131 (81.4)	111 (81.0)	84 (80.0)	132 (85.7)	129 (84.3)	120 (79.5)
Ex-smoker	25 (12.8)	24 (14.9)	24 (17.5)	15 (14.3)	14 (9.1)	21 (13.7)	22 (14.6)
C-smoker	4 (2.1)	6 (3.7)	2 (1.5)	6 (5.7)	8 (8.0)	3 (2.0)	9 (6.0)
<i>p</i> value	0.007*	0.1	0.001*	0.199	0.078	0.075	0.011*
Family H							
Yes	159 (81.5)	129 (80.1)	112 (81.8)	89 (84.8)	123 (79.9)	114 (74.5)	122 (80.8)
No	36 (18.5)	32 (19.9)	25 (18.2)	16 (15.2)	31 (20.1)	39 (25.5)	29 (19.2)
<i>p</i> value	0.254	0.98	0.474	0.114	0.875	0.003*	0.749
Duration, y							
1–5	22 (11.3)	19 (11.8)	13 (9.5)	11 (10.5)	17 (11.0)	21 (13.7)	16 (10.6)
5–10	47 (24.1)	43 (26.7)	36 (26.3)	20 (19.0)	34 (22.1)	33 (21.6)	33 (21.9)
10–15	58 (29.7)	46 (28.6)	42 (30.7)	36 (34.3)	50 (32.5)	43 (28.1)	52 (34.4)
15–20	40 (20.5)	30 (18.6)	25 (18.2)	23 (21.9)	32 (20.8)	31 (10.5)	25 (16.6)
20–25	21 (10.8)	16 (9.9)	15 (10.9)	11 (10.5)	16 (10.4)	16 (10.5)	16 (10.6)
>25	7 (3.6)	7 (4.3)	6 (4.4)	4 (3.8)	5 (3.2)	9 (5.9)	9 (6.0)
<i>p</i> value	0.199	0.816	0.911	0.45	0.436	0.126	0.328

*Significant ($p < 0.05$).

H = history; L = lower; U = upper.

asking whether the subject strongly felt that a food item(s) was indeed associated with triggering or aggravating an attack of asthma. A total of 22 food items from focus group and preliminary study were recognized as potential food allergens in patients from this area. Those reporting no association with a food item and those who were not certain about the association were not included for further interview regarding the association of a food allergen with demographic variables and IgE levels.

Those subjects strongly acknowledging at least 1 food item to be associated with their asthma were further interrogated in part 2 of the questionnaire regarding age, sex, SES, smoking, family history of asthma, and duration of illness. Total serum IgE levels, however, were determined by enzyme-linked

immunosorbent assay (ELISA) using Elagen total IgE (Adaltis srl, Rome, Italy) in all subjects. A detailed history of the relationship between consumption of several allergenic food-stuffs (available in the region) and occurrence of perceived food allergy was included in the open-ended questionnaire. Specific foods were suspected as causative when asthmatic symptoms (i.e., wheeze, cough and breathlessness, chest pain, and expectoration) were clearly related to food ingestion.

Statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) for Windows, version 15.0 (SPSS Inc, Chicago, IL). Data were analyzed using a χ^2 test. All 22 suspected food items were analyzed against age, sex, SES, family history of asthma, smoking history, and duration/onset of disease. Statistical significance was set at 2-

Table 3. Extended.

Potato, N (%)	Lemon, N (%)	Gram, N (%)	Groundnut, N (%)	Onion, N (%)	Urd, N (%)	Rajma, N (%)	Banana, N (%)	Pea, N (%)
75 (58.1)	101 (53.4)	91 (52.0)	74 (50.7)	72 (51.8)	91 (49.5)	89 (54.6)	99 (53.5)	94 (54.7)
54 (41.9)	88 (46.6)	84 (48.0)	72 (49.3)	67 (48.2)	93 (50.5)	74 (45.4)	86 (46.5)	78 (45.3)
0.025*	0.23	0.787	0.757	0.906	0.246	0.153	0.237	0.112
8 (6.2)	11 (5.8)	10 (5.7)	8 (5.5)	10 (7.2)	14 (7.6)	13 (8.0)	15 (8.1)	13 (7.6)
29 (22.5)	42 (22.2)	34 (19.4)	36 (24.7)	29 (20.9)	38 (2)	35 (21.5)	39 (21.1)	42 (24.4)
28 (21.7)	44 (23.3)	45 (25.7)	37 (25.3)	38 (27.3)	49 (26.6)	37 (22.7)	47 (25.4)	40 (23.3)
64 (49.6)	92 (48.7)	86 (49.1)	65 (44.5)	62 (44.6)	83 (45.1)	78 (47.9)	84 (45.4)	77 (44.8)
0.433	0.129	0.349	0.181	0.824	0.728	0.541	0.728	0.111
7 (5.4)	5 (2.6)	2 (1.1)	0 (0)	5 (3.6)	7 (3.8)	5 (3.1)	3 (1.6)	3 (1.7)
20 (15.5)	24 (12.7)	21 (12.0)	17 (11.6)	14 (10.1)	21 (11.4)	15 (9.2)	22 (11.9)	18 (10.5)
44 (34.1)	51 (27.0)	63 (36.0)	43 (29.5)	38 (27.3)	53 (28.8)	59 (36.2)	56 (30.3)	61 (35.5)
51 (39.5)	77 (40.7)	58 (33.1)	53 (36.3)	63 (45.3)	68 (37.0)	59 (36.2)	71 (38.4)	61 (35.5)
7 (5.4)	32 (16.9)	31 (17.7)	33 (22.6)	19 (13.7)	35 (19.0)	25 (15.3)	33 (17.8)	29 (16.9)
0	0.001*	0.017*	0	0.009*	0.068	0.412	0.062	0.33
107 (82.9)	158 (83.6)	146 (83.4)	121 (82.9)	114 (82.0)	158 (85.9)	141 (86.5)	156 (84.3)	143 (83.2)
18 (14.0)	25 (13.2)	25 (14.3)	19 (13.0)	17 (12.2)	17 (9.2)	14 (8.6)	20 (10.8)	20 (11.6)
4 (3.1)	6 (3.2)	4 (2.3)	6 (4.1)	8 (5.8)	9 (4.9)	8 (4.9)	9 (4.9)	9 (5.2)
0.466	0.273	0.023*	0.718	0.16	0.024*	0.037*	0.197	0.171
105 (81.4)	151 (79.9)	139 (79.4)	118 (80.8)	112 (80.6)	150 (81.5)	132 (81.0)	149 (80.5)	141 (82.0)
24 (18.6)	38 (20.1)	36 (20.6)	28 (19.2)	27 (19.4)	34 (18.5)	31 (19.0)	36 (19.5)	31 (18.0)
0.605	0.833	0.631	0.749	0.852	0.33	0.641	0.787	0.256
14 (10.9)	21 (11.1)	20 (11.4)	14 (9.6)	18 (12.9)	21 (11.4)	21 (12.9)	16 (8.6)	21 (12.2)
41 (31.8)	45 (23.8)	51 (29.1)	38 (26.0)	33 (23.7)	44 (23.9)	39 (23.9)	49 (26.5)	46 (26.7)
41 (31.8)	62 (32.8)	50 (28.6)	45 (30.8)	41 (29.5)	59 (32.1)	53 (32.5)	52 (28.1)	54 (31.4)
21 (16.3)	35 (18.5)	28 (16.0)	27 (18.5)	20 (14.4)	33 (17.9)	24 (14.7)	39 (21.1)	34 (19.8)
12 (9.3)	18 (9.5)	15 (8.6)	12 (8.2)	18 (12.9)	18 (9.8)	21 (12.9)	18 (9.7)	13 (7.6)
0 (0)	8 (4.2)	11 (6.3)	10 (6.8)	9 (6.5)	9 (4.9)	5 (3.1)	11 (5.9)	4 (2.3)
0.002*	0.905	0.018*	0.333	0.053*	0.967	0.012*	0.018*	0.029*

tailed $p < 0.05$. Mean $\pm$ standard deviation was applied to the numeric values of total serum IgE, and an independent sample t -test was applied to find the association between 22 suspected food items and serum IgE.

RESULTS

The demographic profile of subjects with perceived food allergy ($n = 237$) is shown in Table 1. The mean age of study subjects was 33.2 ± 6.6 years. We found that male patients (51.5%) were more allergic to food items on the basis of perception in comparison with female patients (48.6%). Age-wise distribution showed that 7.2%, 20% to 27%, 25.3%, and 46.8% of subjects reported food item allergy in age groups

younger than 10, 10 to 20, 20 to 30, and older than 30 years, respectively. Thus the maximum number of patients reported to be allergic to food items was included in the age group older than 30 years.

Similarly, among different socioeconomic strata (categorized by the Kuppuswamy Scale), 7 of 237 or 3.0%, 26 of 237 or 11.0%, 78 of 237 or 32.3%, 86 of 237 or 36.3%, and 40 of 237 or 16.9% of subjects reported food item allergy in terms of upper, upper middle, lower middle, upper lower, and lower SES, respectively; thus suspected food item allergy in asthmatic patients was highest among patients belonging to the middle class.

Reported food item allergy was higher among those who never smoked (200/237; 84.4%) in comparison with ex-smokers (28/237; 11.8%) and current smokers (9/237; 3.8%).

Table 4. Association between Total Serum IgE and Suspected Food Items

Subject No.	Food Items Reported as Allergens	Frequency, n (%) (N = 261)	IgE, KIU/L		p Value
			Yes, Mean $\pm$ SD	No, Mean $\pm$ SD	
1	Curd	195 (82.3)	668.3 $\pm$ 423.4 (N = 195)	675.4 $\pm$ 419.3 (N = 66)	0.922
2	Lemon	189 (79.7)	670.1 $\pm$ 417.9 (N = 189)	667.6 $\pm$ 441.0 (N = 72)	0.970
3	Banana	185 (78.1)	661.1 $\pm$ 420.3 (N = 185)	699.8 $\pm$ 429.7 (N = 76)	0.559
4	Urd dal/Horse bean	184 (77.6)	677.0 $\pm$ 422.2 (N = 184)	643.8 $\pm$ 423.4 (N = 77)	0.614
5	Gram/Green gram	175 (73.8)	659.1 $\pm$ 420.7 (N = 175)	699.0 $\pm$ 426.8 (N = 86)	0.522
6	Rice	174 (73.4)	682.4 $\pm$ 425.4 (N = 174)	634.2 $\pm$ 413.0 (N = 87)	0.438
7	Green pea	172 (72.6)	685.3 $\pm$ 420.3 (N = 172)	627.8 $\pm$ 426.0 (N = 89)	0.350
8	Milk	169 (71.3)	679.0 $\pm$ 420.4 (N = 169)	646.0 $\pm$ 427.3 (N = 92)	0.587
9	Rajma/Red kidney beans	163 (68.8)	671.3 $\pm$ 424.3 (N = 163)	665.8 $\pm$ 419.0 (N = 195)	0.927
10	Masoor dal/Split red lentil	161 (67.9)	669.9 $\pm$ 415.9 (N = 161)	669.0 $\pm$ 436.8 (N = 100)	0.987
11	Egg	159 (67.1)	671.6 $\pm$ 427.1 (N = 159)	665.5 $\pm$ 413.5 (N = 102)	0.918
12	Orange	154 (65.0)	683.4 $\pm$ 414.8 (N = 154)	644.0 $\pm$ 435.8 (N = 107)	0.494
13	Radish	153 (64.6)	671.5 $\pm$ 425.1 (N = 153)	666.0 $\pm$ 418.1 (N = 108)	0.925
14	Chicken	151 (63.7)	682.7 $\pm$ 431.9 (N = 151)	646.5 $\pm$ 404.9 (N = 110)	0.526
15	Lobhia/Black-eyed beans	151 (63.7)	663.6 $\pm$ 426.6 (N = 151)	680.0 $\pm$ 415.4 (N = 110)	0.773
16	Groundnut	146 (61.6)	665.1 $\pm$ 413.3 (N = 146)	676.8 $\pm$ 437.2 (N = 115)	0.836
17	Fish	144 (60.8)	653.6 $\pm$ 423.7 (N = 144)	694.3 $\pm$ 419.8 (N = 117)	0.469
18	Onion	139 (58.6)	667.0 $\pm$ 417.8 (N = 139)	673.1 $\pm$ 429.4 (N = 122)	0.912
19	Soyabean	137 (57.8)	659.5 $\pm$ 423.2 (N = 137)	683.3 $\pm$ 421.5 (N = 124)	0.669
20	Potato	129 (54.4)	680.8 $\pm$ 415.9 (N = 129)	656.1 $\pm$ 430.1 (N = 132)	0.654
21	Arhar dal/Split red gram	105 (44.3)	755.4 $\pm$ 413.7 (N = 105)	601.3 $\pm$ 417.1 (N = 156)	0.005*
22	Moong/Split green gram	32 (13.5)	596.0 $\pm$ 388.6 (N = 32)	681.1 $\pm$ 426.4 (N = 229)	0.289

*Significant ($p < 0.05$).

The proportion of patients with suspected allergy to food was greater among patients with a positive family history of asthma (80.2%) than among those with no family history of asthma (19.8%). The mean and standard deviation of total serum IgE levels was 669.2 ± 421.6 KIU/L, which was above the range of normalcy (150 KIU/L) in 65% of patients who strongly implicated a food item allergy as related to their asthma.

A list of 22 items was thrown open to respondents to identify or choose from as their candidate item for food-related allergy. Patients suffering from asthma had multiple suspicions toward food. Items included and numbers of subjects who identified a particular item as their allergen were as follows: curd 214 (82.0%), lemon 208 (79.7%), banana 203 (77.8%), urd/horse bean 202 (77.3%), green gram 192 (73.6%), rice 191 (73.2%), green pea 189 (72.4%), milk 186 (71.2%), rajma/red kidney beans 179 (68.6%), masoor/split red lentil 177 (67.8%), egg 175 (67.0%), orange 169 (64.8%), radish 168 (64.3%), chicken 166 (63.6%), lobhia/black-eyed beans 166 (63.6%), groundnut 160 (61.3%), fish 158 (60.5%), onion 152 (58.2%), soyabean 150 (57.5%), potato 141 (54.0%), arhar/split red gram 115 (44.0%), and moong/split green gram 35 (13.5%). Only 27 of 261, or 10.4%, did not think that a food item was associated with triggering or worsening their asthma, and remaining asthmatic patients (90.6%; 237/261) reported at least 1 food item associated with triggering their asthma. Of the 22 putatively recognized food allergens already mentioned, those marked with an asterisk

(Table 2) were found to be significantly associated with 1 of the 6 study variables: age, sex, SES, smoking history, family history of asthma, and duration of illness.

Masoor or split red lentil, arhar or split red gram, and potato were more commonly reported by men as allergens, whereas orange, radish, and chicken significantly affected women more commonly. Those older than 30 years more frequently reported curd, masoor/split red lentil, soyabean, and arhar or split red gram as significantly associated with their asthma as compared with other age groups. Not much difference was noted in perceived food item allergens in the 5 socioeconomic strata, except that in the upper-middle SES, soyabean, lemon, and onion, and in the lower-middle SES, gram were thought of as allergens. Asthmatic individuals who never were smokers were reported to be allergic to curd, soyabean, chicken, gram, urd, and rajma. Current and past smokers, however, did not have important food item associations. Patients with a positive family history of asthma significantly associated radish as an important allergen. Those with less than 10 years of asthma history were reported to be allergic to potato and lemon, and patients with longer than 10 years of asthma history were reported to be allergic to potato, onion, rajma, banana, and green pea (Table 3). Serum total IgE levels were raised above normal levels in all subjects reporting one or another food allergy. However, of 22 food allergens, only arhar or split red gram lentil allergy subjects showed highly significantly raised total serum IgE levels (Table 4).

DISCUSSION

The aim of the present study was to document the food item as allergen as perceived by patients with asthma in our setup. India is a traditional society with age old established dietary practices, and Indian cuisines are world famous. In earlier times, invaders came to India for the famous Indian condiments, and many settled here because of the exotic food. Because of the tropical climate in most of the Indian subcontinent, ice cold and sour food items often may be relegated as allergens. Medical and nutritional published literature from the Indian subcontinent is scant.

We also studied the perceived food allergens and their association with age, sex, SES, family history of asthma, smoking history, duration of illness, and total serum IgE. No such study has been reported from this part of the world until now. Food allergy among patients with asthma attending the doctor's clinic was 90% on the basis of self-perception; this prevalence is much greater when compared with the findings of most previous studies. In a study on 135 adult subjects conducted in Melbourne, Australia, 73% perceived food-induced asthma [23]. Other studies have reported even lower prevalences of 26% and 13% self-reported food allergy in asthmatic patients [24,25]. This study reports 22 food items recognized as food allergens by subjects with asthma on the basis of self-perception. In several such cross-sectional studies, respondents most often pointed out multiple local food items as allergens, for example, one study [26] reported 34 food items as food allergens among subjects with respiratory symptoms, and another study [27] conducted in Australia on adults (20–44 years) reported 31 different types of food items as the cause of their illness. Table 5, which provides a comparison of all published important studies in this area, shows that indeed there exists a hard core food allergen perception throughout the world.

Common food allergens believed to trigger asthma derived from combined worldwide scientific and clinical investigations include milk, eggs, peanuts, tree nuts, soy, wheat, fish, and shellfish [28]. Table 6 has been drawn to summarily illustrate the various food items reported as allergens; the most common among these are shown in bold.

Among more than half of persons with asthma (i.e., 65% in this study) with perceived sensitivity to food, investigators attributed sensitivity to atopy (raised serum IgE levels); this was particularly significant in patients who reported arhar as a food allergen on the basis of perception. This association between arhar allergy and total serum IgE is just an association with the overall allergic component in asthma, and is not an association with clinical reactivity to the specific food.

Earlier studies reported that larger numbers of patients with asthma who had suspected food allergy had high serum IgE levels [24,29–31]. A study done on female adults showed that

IgE molecules were found to play a crucial role in allergic respiratory disease and may cause chronic airway inflammation in asthma through activation of effector cells via high-affinity (Fc RI) or low-affinity (Fc RII) IgE receptors [32].

In the present study, some patients with asthma (35%) reported that food items as allergens had normal total serum IgE concentrations. This is consistent with the findings of other studies [30,33], which failed to demonstrate increased mean serum IgE concentrations and detectable quantities of IgE antibodies to tested food in patients with suspected food allergy. The symptoms of these patients were probably the result of other immunologic or nonimmunologic mechanisms [34,35].

Results describing perceived food allergy and its relationship to demographic parameters are presented here, and similar findings were reported earlier [24]. In complete contrast to findings reported by other authors, men among our subjects with asthma from India perceived food allergy much more frequently than women [24,29,36,37]. The present study showed that most patients with asthma attending the respiratory medicine outpatient department were nonsmokers; this finding contrasts with data from another study, in which smoking was commonly associated with patients with asthma attending hospital clinics; therefore it was considered a risk factor in terms of causation and severity of asthma [38]. A study in Chilean young adults [39] revealed that asthma is most often seen in low socioeconomic classes; this finding was found to be statistically significant. However in the present study, most subjects were members of lower middle (III) and upper lower (IV) socioeconomic classes (categorized by the Kuppuswamy Scale).

Variations in the prevalence of reported food allergens and their association with various demographic features of patients with asthma can be explained by the subjective nature of the relationship between complaints and food consumption patterns, cultural differences, types and frequencies of food items that people generally consume, the various ways in which survey questions were formulated, and the ways that responses were obtained.

Our study data indicate that, after allowing for various confounding factors, patients with asthma who are allergic to food presented with some particular features. Males are at greater risk than females of having perceived food allergy to masoor/split red lentil, arhar/split red gram, and potato. The prevalence of perceived food allergy to curd, masoor/split red lentil, soyabean, and arhar/split red gram was greater in patients with asthma older than 30 years of age. Perceived food allergy to soyabean, lemon, and onion was significantly associated with lower SES. Smoking was not a significant risk factor for having perceived food allergy to studied types of foods. Family history of asthma was a significant risk factor for perceived food allergy to radish, and increased duration of asthma was significantly associated with

Table 5. Comparative Table of Published Important Studies That Shows the Existence of a Hard Core Food Allergen Perception Throughout the World

Ref. No.	Type of Study, Age and No. of Cases	Important/Relevant Findings
Woods et al., 1996 [23]	Hospital-based study, done on asthmatic adults (N = 156 consecutive patients)	• Response rate of questionnaire = 86.5% (134/156). • 73% (98/134) reported food-induced asthma. • Of 98 cases, dietary advice was given to 47% (46/98) of patients, and 61% (59/98) were kept on diet modification/restriction. • Of these, 59 of 98 cases (79%; 46/59) perceived that this had improved their asthma.
Aba-Alkhalil and El-Gamal, 2000 [24]	Cross-sectional hospital-based study (N = 1341 patients with asthma)	• Prevalence of clinical sensitivity to food = 29% (392/1341). • Had multiple food hypersensitivity. • Common suspected 11 food allergens were egg, banana, fish, tomato, citrus fruits, strawberry, nuts, cow's milk, beer, melon, and mushroom. • 64.5% (253/392) had raised total serum IgE levels. • Sensitivity to food was greater over 15 y of age, higher in women, and higher in patients with positive family history. • <i>Citrus fruits</i> were significantly associated with increased risk of asthma at night. • Tomatoes were significantly associated with seasonal fluctuations in asthma attacks. • Egg, beer, melon, citrus fruits, and fish were associated with increased severity and frequency of asthma attacks. • Tomatoes were associated with increased risk of asthma attacks before the age of 15 years. • Tomatoes, bananas, and citrus fruits were associated with increased age of onset and age of patients with asthma. • Cow's milk and strawberry were associated with increased duration of asthma. • Egg, fish, and citrus fruits were associated with positive history of allergy. • Females were at greater risk of having food allergy to mushrooms compared with males. • Positive family history of asthma was a significant risk factor for clinical sensitivity to citrus fruits. • Smoking was not a significant predisposing risk factor for having clinical sensitivity to studied types of foods. • Positive history of allergy to tomatoes, melon, and citrus fruits was significantly associated with increased levels of IgE in the blood. • Positive history of allergy to strawberry was significantly associated with decreased levels of IgE.
Kanny et al., 2001 [25]	Epidemiologic survey, done on ≤60 y (N = 33,110 subjects [phase 1], 1129 subjects with food allergy during phase 1 received a questionnaire for phase 2)	• Reported prevalence of food allergy was 3.52% (1129/33,110). • Most frequent food allergens were vegetables 9%, milk 8%, fruit 5%, egg 4%, tree nuts 3%, and peanut 1% (n = 1129). • Prevalence of food allergy in asthmatic subjects was greater at 4 and 6 y of age.
Zuberbier et al., 2004 [29]	Cross-sectional survey, done on all age groups (N = 4093/13,300 replied to the questionnaire)	• Self-reported prevalence (mean age, 41 y) = 34.9%. • SPT was done for Soyabean and fish, prick-to-prick test was done for apple, potato, carrot, celery, guar gum, barley, wheat, rye, oat, pork, meat, egg, carrageen, carob, cow's milk, soy, herring, mackerel, mussels, crab, hazelnut, walnut, peanut, sesame, and poppy. • Prevalence of self-reported allergic symptoms in allergic asthma was 9.4% lifetime, 6.7% in the last 12 months. • Food Sp IgE was positive in 11.2% for at least 1 of the food allergens (wheat, milk, egg, soy, fish). • Total serum IgE was raised in 39.9% of participants. • When confirmed by elimination diet followed by DBPCFC test, it was 3.6% (for all age groups) and 3.7% in adult population (18–79 y). • Of positive DBPCFC (3.6%), 2.5% IgE mediated (highest freq with 4.3% in age group 20–39 y), females were more frequently affected (60.6%), higher in persons with higher education; foods that elicited IgE-mediated reactions were hazelnut, apple, pineapple, berries, kiwi, and bananas, and 1.1% non-IgE-mediated (highest in age group of 60 y and older, more in females [59.1%]), no association with education.

Table 5. Continued.

Ref. No.	Type of Study, Age and No. of Cases	Important/Relevant Findings
Woods et al., 1998 [26]	Community based survey (N = 757 adults; 20–44 y)	• 25% (167/669) indicated that they had experienced illness caused by eating particular food/foods. • 78% (128/167) or 19% (128/669) with reported illness nearly always had the same illness after eating particular food/foods: 42 of 128 had respiratory symptoms nearly always after eating food, and 17 of 128 had respiratory symptoms alone always after eating food. • 34 food items were cited as causing illness. • No association between food illness and age, gender, BHR, atopy, asthma status, FEV1, BMI, smoking, and allergen immunotherapy. • 42 of 128 of those who had respiratory symptoms nearly always after eating food were more likely to be atopic, used medication in past 12 months, weighed more, and were less likely to have reported exposure to passive smoking over the past 12 months, but incidents were not significantly associated with age, gender, BMI, active smoking status, and allergen immunotherapy. • 17 of 128 had respiratory symptoms alone always after eating food; significantly associated with impaired FEV1.
Woods et al., 2002 [27]	Cohort epidemiologic study (N = 457; done on adults 20–44 y)	• Mean age = 39.2 ± 6.3 y, males = 48%, females = 52%. • Of 457, 99 (22%) reported food items as allergens. • 31 different food items were reported. • But when this was limited to the 5 food allergens of interest (SPT) (cow's milk, peanut mix, whole grain wheat mix, shrimp, and egg), only 54 of 457 (11.8%) reported illness to food. Also, 5 of 49 adults reported illness to more than 1 of the allergens of interest. • The prevalence of reported adverse food reactions with an IgE-mediated immunologic mechanism in general population would be 1.5% (7/457) (i.e., had positive SPT, as well as positive perception).
Onorato et al., 1986 [30]	Hospital-based study (N = 300 consecutive patients with asthma, 7 mo–80 y)	• Of 300 patients, only 25 had suggestive history of food allergy/positive SPT/positive RAST. • Of these 25, 20 patients had interpretable food challenges. • Of these 20, food challenge caused asthma in 6 patients and caused other symptoms in 5 subjects. • On rechallenge after pretreatment with sodium chromoglycate, the asthmatic response was blocked in 4 of 5 subjects. • Most often, patients with asthma and food allergy were young and had high total serum IgE levels.
Satwani et al., 2009 [31]	Cross-sectional comparative study (N = 258 children, 6 mo–12 y)	• 108 of 258 (41.8%) males, 92 of 258 (35.6%) females • 166 of 258 (64.3%) had raised total serum IgE levels. • Serum IgE was associated with weight, early weaning, bottle feeding, exposure to passive smoking, pollen, cold, pets, and severity of disease (in asthmatic subjects). • Serum IgE was not associated with age, sex, height, positive family history, age at which symptoms developed, systemic allergies, skin allergy, food allergy, allergic sinusitis, and allergic rhinitis. • Serum IgE is a strong predictor of allergy in asthmatic children. • Blood eosinophilia was associated with allergy and raised serum IgE levels.
Bender et al., 1981 [37]	Community-based survey (N = 560)	• 13 food items were reported by 1%–4% of respondents. • 33% stated that they avoided 1 or more foods on the basis of perception. • A total of 67 foods were mentioned as causes of adverse food reactions.

increased risk of reported food allergy to potato, onion, rajma/red kidney bean, banana, and pea. Early identification of symptomatic food allergy at a young age followed by avoidance of the food is an important preventive factor for food allergy resolution over time. One study [23] reported a 79% reduction in symptomatic food allergy among adults suffering from asthma when they were kept on diet elimination. This needs to be elucidated in the future using the strategy of food allergen elimination or challenge and

food-specific IgE estimations to further substantiate the claim of food item allergy.

CONCLUSION

In India, individuals with asthma have largely been perceived as having food allergy, as reported by 90% of respondents in this case series. As in many other studies, not

Table 6. Summary to Illustrate the Various Food Items Reported as Allergens

Woods et al., 1998 [26]	Aba-Alkhail and El-Gamal, 2000 [24]	Kanny et al., 2001 [25]	Woods et al., 2002 [27]	Jain et al. (present study)
34 food items were cited as causing illness:	11 common suspected food allergens were:	Most frequent food allergens were:	31 different reported food items were:	22 reported food items as allergens on the basis of perception:
Fruits , fresh/frozen/canned	Eggs	Vegetables	Dairy products	Curd
Seafood /shellfish/fish	Banana	Milk	Fruits	Lemon
Dairy products , milk/cheese/yogurt/ice cream	Fish	Fruits	Seafood	Banana
Herbs/spices /condiments/garlic/chili	Tomato	Egg	Monosodium glutamate	Urd/horse bean
Monosodium glutamate	Citrus fruits	Tree nuts	Alcohol	Gram/green gram
Alcohol	Strawberry	Peanut	Herbs/Spices	Rice
Eggs	Nuts		Dried fruits	Green pea
Fats/oils, butter/margarine/cream/salad dressing	Cow's milk		Fats/oils	Milk
Chocolate	Beer		Eggs	Rajma/red kidney beans
Vegetables , fresh/frozen/canned	Melon		Nuts	Masoor/split red lentil
Red meat , fresh	Mushroom		Chocolate	Egg
High-fat foods			Restaurant meals/take away	Orange
Nuts , including peanut butter/coconut			Vegetables	Radish
Wheat products , bread/plain cereals			Red meat	Chicken
Sugar , including golden syrup/jam			Preservatives	Lobia/black-eyed beans
Restaurant meals/take away			Fruit juice	Groundnut/peanut
Fruits, dried			Gluten	Fish
Sauces , including tomato paste/seasonings			Wheat products	Onion
Tea/coffee			Sauces	Soyabean
Poultry			High-fat foods	Potato
Spicy foods			Soft drinks/cordials, other	Arhar/split red lentil
Processed meats, including ham/bacon			Yeast	Moong/split green gram
Other (12 separate items cited)			Artificial colors	
			Poultry	
			Pickled vegetables	
			Sweet biscuits/cakes	
			Tea/coffee	
			High-sugar foods	
			Acidic foods	
			Spicy food	
			Miscellaneous mixed dishes	

one but several food items were perceived by patients as allergens; 22 commonly consumed food items were identified in this study. Of these, 16 food items were significantly associated with demographic profile, family history, duration of asthma, and smoking. Reported food allergy was mostly atopic as confirmed by serum total IgE levels. Food challenge, diet elimination, and food-specific atopic serum markers remain to be elucidated by further study of these data. Causal relationships to individual food items were not determined. The associations found to be related to reporting of food-related symptoms require further investigation and verification in prospective studies. Causal relationships should not be inferred from these results alone. We can proceed further by performing food-specific IgE to find out the specificity of food items as food allergens in asthmatic individuals, if this type of diet elimination can be done.

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