

## Indoor Mycoflora in Household Dust and Human Health

Mohamed A. Fareid

Botany and Microbiology Dept., Faculty of Science, Al-Azhar University  
Present address: Medical Microbiology Dept., Faculty of Medicine, H'ail University, SA.  
[mohamedfareid73@yahoo.com](mailto:mohamedfareid73@yahoo.com)

**Abstract:** Indoor mycoflora in household dust were assessed by using conventional methods to investigate the enumeration and identification of mycoflora. The dust samples were collected during the spring season (March-May, 2011) from indoor of homes in different localities of Ha'il, Saudi Arabia. A total of six fungal genera were determined. The most frequency of these was *Aspergillus* (54.45%), *Penicillium* (21.63%), *Fusarium* (8.91%), followed by *Trichoderma* (6.96%) colonies. Also, a total of two yeasts genera were determined. The most frequency one of these was *Candida* (60.77%) colonies. Statically our results indicated that there was a highly significant different in temperatures and wind speed during March, April and May ( $P = 0.001$ ), while there was no significant different in humidity ( $P > 0.05$ ). Serum IgE (total and specific) antibody levels to 13 different fungal species in 76 patients with asthma (adults and children's) were studied. The number of allergen-specific IgE measurements above the cut-off ( $> 0.35$  kUA/L) was highly significant different for all fungal species tested ( $P = 0.001$ ). There were significant correlations between total IgE level and specific IgE to *Aspergillus repens* ( $r = 0.332$ ,  $P < 0.05$ ), *Trichoderma viride* ( $r = -0.332$ ,  $P < 0.05$ ) and *Candida albicans* ( $r = 0.298$ ,  $P < 0.05$ ).

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### 1. Introduction

Fungi, ubiquitous unicellular or multicellular organisms, exist in several forms, including single-celled yeasts, microscopic filaments (hyphae), aggregates of these filaments (mycelia), and spore producing visible fruiting bodies (e.g., mushrooms). Fungi represent about 10% of the earth's biomass and serve to recycle organic matter. They grow on a wide variety of indoor and outdoor organic substrates, with water (moisture) the most important factor for determining growth for many species. Molds can grow on cloth, carpets, leather, and wood and on human foods when moist conditions exist (Gravesen, *et al.*, 1999). Modern houses provide a new ecological niche for fungi as a result of reduced ventilation and extensive use of air conditioning, especially during summer time. Dust formation occurs as a result of the ongoing elutriation of airborne organic and inorganic particulate matter that originates from a multiplicity of indoor and outdoor sources. Fungi along with mites pose great health hazards to the residents of these houses (Rijckaert, 1981; Schoeber, 1988; Bokhary and Parvez, 1995). These fungal components, mites and pollen grains cause several allergic diseases like asthma, rhinitis, nasal eosinophilia and dermatitis (Chirila *et al.*, 1984; Krillis *et al.*, 1985 and Al-Fryah *et al.*, 1989). Children's are

more susceptible to these diseases than adults (Mori *et al.*, 1985; Bronswijk *et al.*, 1986).

In recent years, the quality of indoor air has been the subject of several studies. Conditions increasing air humidity, decreased ventilation and increased moisture level subsequently increase the proliferation of fungi and bacteria (Ruest, 2004). These fungal elements may cause severe illness as a result of indoor mold exposure including pulmonary, immunologic, neurologic and oncologic disorders (Kuhn and Ghannoum, 2003). Researcher believed that, more than 80 genera of fungi are associated with symptoms of respiratory tract allergies (Horner *et al.*, 1995). Over 100 species of fungi were involved with serious human and animal infections (Cvetnic and Pepeljnjak, 1997). *Alternaria*, *Cladosporium*, *Aspergillus*, *Penicillium* and *Fusarium* were among the most common allergenic genera, for instance, elevated concentration of *Cladosporium* were usually associated with respiratory symptom (Su *et al.*, 1992).

Fungi can cause adverse health effects in human beings through harmful immune response, such as allergy and hypersensitivity pneumonitis, by toxic or irritant effects, or by direct infection. Thus, unlike many other airborne allergens, fungi are associated with a variety of illnesses besides IgE-mediated allergy. More

than 80 fungal genera are currently recognized as being associated to allergy, and some of the most frequently occurring are *Cladosporium*, *Penicillium*, *Aspergillus*, *Alternaria*, and *Aureobasidium* (Simon-Nobbe, *et al.*, 2008; Cramer, *et al.*, 2009). During the last decade, a variety of fungal allergens have been described in the literature, including those that are mainly genus-specific (such as the *Alternaria alternata* allergen Alt a 1 and its homologs in other species of genus *Alternaria*) as well as those present in various fungi (Simon-Nobbe, *et al.*, 2008; Cramer, *et al.*, 2009). There is no any study of this issue in Ha'il region. Hence, this work represents an attempt for studying the occurrence and distribution of fungi inhabiting indoor household dust samples as well as assessed the quantity and relationships of specific antibodies to fungi of a group of asthmatic patients. Blood samples were drawn and the amounts of total and specific serum IgE were determined. The association between the fungal colonies and specific and IgE levels was evaluated.

## 2. Material and Methods

Ha'il City is the provincial capital of Ha'il Province in northern Saudi Arabia, which covers a land area of about 120,000 square kilometers, about 6% of the total land area of the Kingdom of Saudi Arabia. Ha'il is located 700 kilometers northwest of Riyadh, 400 kilometers northeast of Medina, 300 kilometers southwest of the settlement of Rafha near the border with Iraq, 600 kilometers south of the settlement of Qurayyat near the border with Jordan. Ha'il city lies between the peaks of Aja (about 1,400 meters) and Salma (about 1,100 meters), two mountain ranges at the northern end of the Nejd plateau of the Arabian Peninsula.

### 2.1. Collection of House Dust Samples

Forty seven samples were collected from indoor of home in different localities of Ha'il during the spring season (March to May, 2011). Floor dust of bedrooms, living rooms, filters of air-conditions and window frames were mixed to give a composite sample for each home. Each dust sample was kept in clean plastic bag at 4-6°C until processed.

### 2.2. Isolation of Fungi

Ten mg of each dust sample were transferred aseptically to 9 mm sterile Petri dish. Ten ml of the appropriate medium were added; hand swirled and left

to solidify. Then Petri dishes were incubated at 28°C for 5-7 days. Count (C) of colony forming units per g dust (CFU/g dust) and percentage of total count (%) were calculated.



Figure 1. The map of Ha'il City.

## 2.3. Culture Media

### 2.3.1. Sabouraud's dextrose agar (SDA)

Peptone, 10 g; dextrose, 40 g and agar, 15g in 1000 ml distilled water were used for isolation of xerophilic fungi.

### 2.3.2. Yeast glucose agar

Yeast extract, 5g; glucose, 10g and agar, 15g in 1000 ml distilled water were used for isolation of thermophile yeasts and fungi.

### 2.3.3. Potato dextrose agar (PDA)

Potato infusion solid, 4g; dextrose, 20g and agar 15g in 1000 ml distilled water were used for the identification of fungi and yeasts in parallel with their cellular morphology and enumeration.

## 2.4. Identification of fungi

Cultural characters were assessed visually and by microscopic examination. Pure culture of the fungal isolates were identified according to the following descriptive manuals, Morton and Smith (1963); Raper and Fennell (1965); Ajello (1968); Ames (1969); Rifai (1969); Ellis (1971 & 1976); Booth (1977); Domsch *et al.* (1980); Pitt (1985); Moubasher (1993); Bokhary and Parvez (1995).

## 2.5. Patients

Seventy six patients with asthma were studied. Their ages ranged from 4 to 73 years, with 18 individuals under the age of 17 years (defined as children in this article). The clinical diagnosis of patients was based on finding the characteristic chronic respiratory disease (asthma, rhinitis, or both). The sera from patients with asthma were compared with sera from a group of sixty six non-asthmatic patients (control group), including 50 adults and 16 children. The sera in the asthma group were obtained from random patients who presented with asthma to either of two hospital emergency departments in Ha'il region.

## 2.6. Measurements of total IgE and allergen specific antibodies

The sera of the asthma and control groups were initially assessed by using CAP system for total IgE and specific IgE antibody. Sera were first assayed undiluted, and when necessary, assays were repeated with the sera diluted to enable quantitative measurement of specific IgE antibodies. Measurements of specific IgE were performed by using a flouoroimmunoassay CAP system (Phadia, Uppsala, Sweden). Total IgE for sera from patients with asthma was also measured by using the CAP system. Results are reported quantitatively using a kilo unit per liter scale (kU/L). The calibrator is IgE bound to anti-IgE by using a 6-point quantitative curve. Calibration ranges from < 0.35 kU/L to >100 kU/L. Because there have been changes in assignment of negative test results over the years (listed as < 0.35, 0.0, or as the actual measured values between 0 and 0.35), all values below this cut-off level were set to 0.35 kUA/L (Pastorello, *et al.*, 1991; Yaman, 2001).

## 2.7. Statistical analysis

The statistical SPSS version 15 was used in data analysis. Data were represented as mean  $\pm$  SD. ANOVA followed by Duncan test and *t*-test were used to compare the means of the observed results. Correlation coefficients were generated by using the Pearson method. The confidence interval used for all statistical analyses was 95%. *P*-values less than 0.05 were significant.

## 3. Results

Ha'il is a city in Nejd in northwestern Saudi Arabia. It is the capital of the Ha'il Province. It lies on latitude 27°31'N and longitude 41°41'E. The city has a

population of 356,876 according to Ha'il Province.

### 3.1. Meteorological measurements in Ha'il city

Table (1) represented the average meteorological measurements in Ha'il city. Our results indicated that temperatures degrees were increased gradually through the period from March till May, 2011. The average measurements of temperatures recorded 22.1, 27.3 and 33.1°C, respectively. Metrological data showed that humidity was higher during March (27.5%), while wind speed recorded a higher level at April (37.5 km/hr). Statically our results indicated that there was a highly significant different in temperatures and wind speed during March, April and May ( $P = 0.001$ ), while there was no significant different in humidity ( $P > 0.001$ ).

### 3.2. The fungal fluctuation of indoor house dust in spring

Fungal fluctuation of indoor house dust was represented in table 2. A total of 6 genera were determined. The most common of these were *Aspergillus* (54.45%) colonies, *Penicillium* (21.63%) colonies, *Fusarium* (8.91%) colonies, followed by *Trichoderma* (6.96%) colonies, through March 2011. The genus *Aspergillus* was represented in five species, *Aspergillus niger* (7.39%), *Aspergillus repens* (13.59%), *Aspergillus flavus* (21.52%), *Aspergillus fumigatus* (7.28%) and *Aspergillus terreus* (4.67%), while the genus *Penicillium* represented in only two species, *penicillium glabrum* (15.87%) and *Penicillium verrucosum* (5.76%). Statically our results indicated that there was a highly significant different in the number of colonies during March, April and May month's ( $P < 0.05$ ).

### 3.3. The yeasts fluctuation of indoor house dust in spring

Table (3) represented the yeasts fluctuation of indoor house dust in spring. A total of two genera were determined. The most common one of these was *Candida* (60.77 %) colonies followed by *Trichosporon* (39.23 %), through April, 2011. Our results statically showed that there was a highly significant different in the number of colonies during March, April and May month's ( $P = 0.001$ ).

**Table 1. Average meteorological measurements in Ha'il city, Saudi.**

Months	Temperature (°C)	Humidity (%)	Wind speed (km/hr.)
March	22.1	27.5	21.6
April	27.3	25.8	37.5
May	33.1	22.3	31.3
<i>P</i> -value	0.001	0.421	0.001

**Table 2. The fungal fluctuation of indoor house dust in spring.**

Fungi	No. of colonies per gram of house dust						F	<i>P</i> -value
	March		April		May			
	CFU/gm.	%	CFU/gm.	%	CFU/gm.	%		
<i>A. alternata</i>	3.2±0.2a	3.48	4.0±0.4ab	3.2	4.5±0.7b	3.28	5.61	0.042
<i>A. niger</i>	6.8±0.4a	7.39	8.9±0.3b	7.12	9.4±0.4b	6.84	41.78	0.001
<i>A. repens</i>	12.5±0.5a	13.59	15.7±0.5b	12.56	17.8±0.5c	12.95	85.48	0.001
<i>A. flavus</i>	19.8±0.5a	21.52	27.8±0.3b	22.24	28.5±0.5b	20.74	356.39	0.001
<i>A. fumigatus</i>	6.7±0.5a	7.28	8.8±0.3b	7.04	10.4±0.4c	7.57	61.98	0.001
<i>A. terreus</i>	4.3±0.3a	4.67	5.6±0.5b	4.48	6.2±0.2b	4.51	22.34	0.002
<i>F. solani</i>	8.2±0.2a	8.91	10.8±0.5b	8.64	12.4±0.4c	9.02	89.86	0.001
<i>P. glabrum</i>	14.6±0.4a	15.87	21.8±0.8b	17.44	23.7±0.2c	17.25	246.89	0.001
<i>P. verrucosum</i>	5.3±0.3a	5.76	7.5±0.3b	6.00	8.5±0.2c	6.19	109.63	0.001
<i>R. oryzae</i>	4.2±0.2a	4.57	6.3±0.2b	5.04	7.4±0.4c	5.39	99.12	0.001
<i>T. viride</i>	6.4±0.4a	6.96	7.8±0.4b	6.24	8.6±0.3c	6.26	27.22	0.001

**Table 3. The yeasts fluctuation of indoor house dust in spring.**

Yeasts	No. of colonies per gram of house dust						F	<i>P</i> -value
	March		April		May			
	CFU/gm.	%	CFU/gm.	%	CFU/gm.	%		
<i>C. albicans</i>	17.9±0.7a	58.12	26.8±0.8b	60.77	33.2±0.2c	60.14	454.17	0.001
<i>T. cutaneum</i>	12.9±0.5a	41.88	17.3±0.3b	39.23	22.5±1.0c	39.86	133.63	0.001

### 3.4 Concentrations of serum total IgE levels and specific IgE antibodies of 76 patients with Asthma

The serum levels of total IgE and specific IgE antibodies to fungi in 76 patients (58 adult and 18 children) with Asthma were investigated. The serum assays of specific IgE antibodies demonstrate that many of the patients with asthma had serum IgE antibodies directed against fungi that are characteristically inhaled (*A. alternata*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *Fusarium solani*, *penicillium glabrum*, *P. verrucosum*, *Rhizopus oryzae* and *Trichoderma viride*) and also to colonizing fungi (*C. albicans* and *Trichosporon cutaneum*; Table 4). All the patients (adults and children's) with asthma also had

very high total and specific serum IgE levels. Serum levels of specific IgE (in adult patient's) to *A. alternata*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *penicillium glabrum*, *P. verrucosum* and *Candida albicans* were 3.80±0.5, 3.22±0.5, 3.66±0.5, 3.96±0.4, 3.88±0.4, 3.25±0.4, 3.86±0.5, 3.45±0.5 and 3.58±0.6 KU/L, respectively. Whereas specific IgE antibody to *A. fumigatus* was much more common in children's than in adults (4.53±0.3 KU/L). Statically our results were indicated that there was a highly significant different in serum total IgE levels and specific IgE antibodies between adults and children's ( $P < 0.05$ ).

**Table 4. Serum total IgE and specific IgE antibodies levels to fungi in 76 patients with Asthma.**

Fungi	Adult (n=58)		Children (n=18)		P-value
	Mean (KU/L)	Prevalence	Mean (KU/L)	prevalence	
IgE to <i>Alternaria alternata</i>	3.80±0.5	(49/58)	2.85±0.2	(8/18)	0.001
IgE to <i>Aspergillus niger</i>	3.22±0.5	(51/58)	2.25±0.3	(12/18)	0.001
IgE to <i>Aspergillus repens</i>	3.66±0.5	(45/58)	2.57±0.2	(9/18)	0.001
IgE to <i>Aspergillus flavus</i>	3.96±0.4	(47/58)	2.40±0.3	(14/18)	0.001
IgE to <i>Aspergillus fumigatus</i>	3.88±0.4	(54/58)	4.53±0.3	(15/18)	0.001
IgE to <i>Aspergillus terreus</i>	3.25±0.4	(39/58)	2.53±0.2	(11/18)	0.001
IgE to <i>Fusarium solani</i>	2.89±0.4	(35/58)	1.86±0.2	(3/18)	0.001
IgE to <i>Penicillium glabrum</i>	3.86±0.5	(56/58)	2.58±0.3	(7/18)	0.001
IgE to <i>Penicillium verrucosum</i>	3.45±0.5	(53/58)	2.31±0.2	(6/18)	0.001
IgE to <i>Rhizopus oryzae</i>	2.99±0.3	(43/58)	1.65±0.2	(5/18)	0.001
IgE to <i>Trichoderma viride</i>	2.84±0.6	(48/58)	1.50±0.2	(9/18)	0.001
IgE to <i>Candida albicans</i>	3.58±0.6	(50/58)	2.12±0.4	(10/18)	0.001
IgE to <i>Trichosporon cutaneum</i>	2.25±0.6	(46/58)	1.75±0.4	(12/18)	0.017
Total IgE	93.88	--	46.57	--	--

### 3.5. Comparison of serum total IgE level and specific IgE antibodies between asthmatic patients and non-asthmatic (control group)

The results for sera of patients with asthma disease were compared with non-asthmatic (control group) sera for concentration of specific IgE antibody to *A. alternata*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *Fusarium solani*, *penicillium glabrum*, *P. verrucosum*, *Rhizopus oryzae*, *Trichoderma viride*, *Candida albicans* and *Trichosporon cutaneum* (Table 5). Mean specific IgE was higher in sera from patients with asthma for all antigens. Our results showed that statically there was a highly significant different in the concentrations of specific IgE levels between asthmatic and non-asthmatic patient's ( $P = 0.001$ ). Analyzing the data for adults and children's separately, serum total IgE level and specific IgE antibodies between adult asthmatic patients were detected in a higher levels than in children's asthmatic patients. Specific IgE to *A. alternata* in asthmatic patients (adults and children's) was  $3.80 \pm 0.5$  and  $2.85 \pm 0.2$ , while as in non-asthmatic (control group) was  $0.12 \pm 0.3$  and  $0.12 \pm 0.2$ , respectively.

### 3.6. Correlations were detected between serum total IgE levels and specific IgE levels to fungi

Table (6) summarized the correlations between serum total IgE levels and specific IgE levels to fungi in the patients with asthma. There were significant correlations between total IgE level and specific IgE to *Aspergillus repens* ( $r = 0.332$ ,  $P < 0.05$ ), *Trichoderma viride* ( $r = -0.332$ ,  $P < 0.05$ ), and *Candida albicans* ( $r = 0.298$ ,  $P < 0.05$ ). While there were no significant correlations between total IgE level and specific IgE to *A. alternata* ( $r = 0.050$ ,  $P > 0.05$ ), *Aspergillus niger* ( $r = 0.088$ ,  $P > 0.05$ ), *A. flavus* ( $r = -0.226$ ,  $P > 0.05$ ), *A. fumigatus* ( $r = 0.006$ ,  $P > 0.05$ ), *A. terreus* ( $r = 0.297$ ,  $P > 0.05$ ), *Fusarium solani* ( $r = -0.094$ ,  $P > 0.05$ ), *Penicillium glabrum* ( $r = -0.186$ ,  $P > 0.05$ ), *P. verrucosum* ( $r = 0.208$ ,  $P > 0.05$ ), *Rhizopus oryzae* ( $r = -0.219$ ,  $P > 0.05$ ), and *Trichosporon cutaneum* ( $r = -0.027$ ,  $P > 0.05$ ). Also there were significant correlations between specific IgE to *Aspergillus repens*, and specific IgE to *A. flavus* ( $r = 0.497$ ,  $P < 0.01$ ), *Penicillium glabrum* ( $r = 0.343$ ,  $P < 0.05$ ), *P. verrucosum* ( $r = 0.457$ ,  $P < 0.01$ ) and *C. albicans* ( $r = 0.895$ ,  $P < 0.01$ ). The rest of the studied correlations were listed in table (6).



Table 5. Comparison of serum total IgE level and specific IgE antibodies between asthmatic patients and non-asthmatic.

Fungi	Patients				Control group				P-value
	Adult (n=58)		Children (n=18)		Adult (n=50)		Children (n=16)		
	Mean	Prevalence	Mean	Prevalence	Mean	Prevalence	Mean	Prevalence	
IgE to <i>A. alternata</i>	3.80±0.5**	(49/58)	2.85±0.2**	(8/18)	0.12±0.3	(49/50)	0.12±0.2	(7/16)	0.001
IgE to <i>A. niger</i>	3.22±0.5**	(51/58)	2.25±0.3**	(12/18)	0.20±0.1	(45/50)	0.04±0.1	(11/16)	0.001
IgE to <i>A. repens</i>	3.66±0.5**	(45/58)	2.57±0.2**	(9/18)	0.22±0.2	(48/50)	0.09±0.2	(10/16)	0.001
IgE to <i>A. flavus</i>	3.96±0.4**	(47/58)	2.40±0.3**	(14/18)	0.10±0.3	(43/50)	0.07±0.1	(13/16)	0.001
IgE to <i>A. fumigatus</i>	3.88±0.4**	(54/58)	4.53±0.3**	(15/18)	0.12±0.2	(40/50)	0.02±0.1	(8/16)	0.001
IgE to <i>A. terreus</i>	3.25±0.4**	(39/58)	2.53±0.2**	(11/18)	0.21±0.1	(39/50)	0.13±0.2	(11/16)	0.001
IgE to <i>F. solani</i>	2.89±0.4**	(35/58)	1.86±0.2**	(3/18)	0.23±0.1	(41/50)	0.12±0.2	(10/16)	0.001
IgE to <i>P. glabrum</i>	3.86±0.5**	(56/58)	2.58±0.3**	(7/18)	0.13±0.2	(44/50)	0.05±0.1	(14/16)	0.001
IgE to <i>P. verrucosum</i>	3.45±0.5**	(53/58)	2.31±0.2**	(6/18)	0.11±0.1	(37/50)	0.03±0.1	(6/16)	0.001
IgE to <i>R. oryzae</i>	2.99±0.3**	(43/58)	1.65±0.2**	(5/18)	0.20±0.1	(36/50)	0.12±0.1	(9/16)	0.001
IgE to <i>T. viride</i>	2.84±0.6**	(48/58)	1.50±0.2**	(9/18)	0.09±0.2	(38/50)	0.01±0.2	(10/16)	0.001
IgE to <i>C. albicans</i>	3.58±0.6**	(50/58)	2.12±0.4**	(10/18)	0.21±0.3	(49/50)	0.10±0.1	(13/16)	0.001
IgE to <i>T. cutaneum</i>	2.25±0.6**	(46/58)	1.75±0.4**	(12/18)	0.12±0.2	(38/50)	0.08±0.2	(8/16)	0.017
Total IgE	93.88	--	46.57	--	0.30	--	0.22	--	--

\*\* . It means highly significant at  $P < 0.001$

Table 6. Correlation coefficient between serum total IgE levels and IgE antibodies to fungi.

No.	IgE level	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Total IgE	1	0.050	0.088	0.332*	-0.226	0.006	0.297	-0.094	-0.186	0.208	-0.219	-0.332*	0.298*	-0.027
2	IgE to <i>A. alternate</i>		1	0.527**	-0.157	-0.200	0.131	0.142	-0.353*	-0.310*	0.195	-0.245	-0.251	-0.181	0.129
3	IgE to <i>A. niger</i>			1	-0.064	-0.157	0.192	0.566**	-0.308	-0.180	0.381**	-0.198	-0.128	-0.042	-0.033
4	IgE to <i>A. repens</i>				1	0.497**	-0.062	-0.105	0.114	0.343*	0.457**	-0.149	-0.052	0.895**	0.064
5	IgE to <i>A. flavus</i>					1	-0.099	-0.335*	0.090	0.854**	0.155	-0.073	0.056	0.373**	-0.096
6	IgE to <i>A. fumigatus</i>						1	0.161	0.421*	-0.152	0.110	0.218	0.071	-0.049	0.219
7	IgE to <i>A. terreus</i>							1	-0.210	-0.294	0.230	-0.153	-0.235	0.026	-0.030
8	IgE to <i>F. solani</i>								1	0.084	-0.023	0.454**	0.288	0.090	0.174
9	IgE to <i>P. glabrum</i>									1	0.149	-0.045	0.054	0.249	-0.089
10	IgE to <i>P. verrucosum</i>										1	-0.233	-0.230	0.393**	-0.011
11	IgE to <i>R. oryzae</i>											1	0.223	-0.274	-0.049
12	IgE to <i>T. viride</i>												1	-0.199	0.177
13	IgE to <i>C. albicans</i>													1	0.121
14	IgE to <i>T. cutaneum</i>														1

\*\* . Correlation is significant at the 0.01 level.

\* . Correlation is significant at the 0.05 level.

#### 4. Discussion

The present study was started on March, up to the end in May, 2011. This study is based on the isolation, identification and assessment of mycoflora from indoor of home in different localities of Ha'il as well as assessed the quantity and relationships of specific IgE antibodies to fungi of a group of asthmatic patients. Saudi Arabia is a country with very little rainfall occurrence per year. Along the time, the country experiences sandstorms thus increasing the propensity of indoor household fungal contamination. Four previous studies on fungal flora in house dust samples in Riyadh conducted in 1990, 1999, 2010 and 2011 reported higher concentrations of fungal colonies in the room air conditioner and living room compared to other locations of the house, with *Aspergillus* predominating the isolated colonies (Saad and El-Gindy, 1990; Bahkali and Parvaez, 1999; Al-Humiany, 2010; Alwakeel and Nasser, 2011). Similarly our works indicated that there was a total of 13 fungal species isolated from household dusts, these mycoflora were represented in the following genera *A. alternate*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *Fusarium solani*, *penicillium glabrum*, *P. verrucosum*, *Rhizopus oryzae*, *Trichoderma viride* *Candida albicans* and *Trichosporon cutaneum*.

In a study conducted in 2004, *Aspergillus* spp. was the most prevalent fungal isolate present in 31-40% of samples followed by *Penicillium* spp. and *Cladosporium* spp. (Pieckova and Wilkins, 2004). The results from several studies showed that there is a direct correlation between the levels of mycofloral contamination in household dust to the occurrence of respiratory diseases, especially asthma and sinusitis (De Blay, 2000; Salo *et al.*, 2005; Woodcock *et al.*, 2006; Cho, *et al.*, 2008 and Porter *et al.*, 2009). In contrast, our study showed that a total of 6 genera were determined. The most common of these were *Aspergillus* (54.45%) colonies, *Penicillium* (21.63%) colonies, *Fusarium* (8.91%) colonies, followed by *Trichoderma* (6.96%) colonies, through March 2011. The genus *Aspergillus* was represented in five species, *Aspergillus niger* (7.39%), *Aspergillus repens* (13.59%), *Aspergillus flavus* (21.52%), *Aspergillus fumigatus* (7.28%) and *Aspergillus terreus* (4.67%), while the genus *Penicillium* represented in only two species, *penicillium glabrum* (15.87%) and *Penicillium verrucosum* (5.76%). Similar findings are reported by Hashem (2008), when studied air-borne mycoflora in

the schools environment in Hofuf city, Al Hassa Province of Saudi Arabia. He found that, genus *Aspergillus* was the most predominant and showed the highest number of cfu/m<sup>3</sup> of air followed by *Penicillium*, *Cladosporium*, *Fusarium*, *Rhodotorula*, *Mucor*, *Alternaria*, *Acremonium*, *Curvularia*, *Stachybotrys*, *Rhizopus*, *Drechslera* and *Ulocladium*.

Statically our results indicated that there was a highly significant different in the number of colonies during March, April and May ( $P < 0.05$ ). Also, finding in this work meteorological studies showed that fungal distribution had a close relationship ( $P = 0.001$ ) with temperature and wind speed. Metrological data showed that humidity was higher during March (27.5%), while wind speed recorded a higher level at April (37.5 km/hr.). Statically our results indicated that there was a highly significant different in temperatures and wind speed during March, April and May ( $P = 0.001$ ), while there was no significant different in humidity ( $P > 0.05$ ). Similar study was carried out by Murat *et al.*, (2006) in Trabzon, Turkey. They found that, there was some degrees of seasonal variations of the major genera were detected; the most notable ones were *Aspergillus* and *Alternaria* genus in that they were in higher numbers in the autumn and in summer, respectively.

Our study showed that serum levels of specific IgE (in adult patient's) to *A. alternate*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *penicillium glabrum*, *P. verrucosum* and *Candida albicans* were  $3.80 \pm 0.5$ ,  $3.22 \pm 0.5$ ,  $3.66 \pm 0.5$ ,  $3.96 \pm 0.4$ ,  $3.88 \pm 0.4$ ,  $3.25 \pm 0.4$ ,  $3.86 \pm 0.5$ ,  $3.45 \pm 0.5$  and  $3.58 \pm 0.6$  KU/L, respectively. Whereas specific IgE antibody to *A. fumigatus* was much more common in children's than in adults ( $4.53 \pm 0.3$  KU/L), this results was in contrast with Jenny *et al.*, 2005. Statically our results were indicated that there was a highly significant different in serum total IgE levels and specific IgE antibodies between adults and children's ( $P < 0.05$ ). In contrast to our study Scalabrin *et al.*, (1999) were evaluated IgE antibodies to potential skin-colonizing organisms, including *Malassezia*, *Candida*, and *Trichophyton* species, and compared them with antibodies to fungi that are generally referred to as sources of inhalant allergens (e.g. *Alternaria* and *Aspergillus* species) and dust mite. The first conclusion of his study was that IgE antibodies to all fungi tested are common among patients with AD, and in many cases the absolute levels are very high (*i.e.*  $\geq 20$  ng of IgE antibody/ ml; CAP class 4). Furthermore, IgE antibodies to *A. alternata* and *M. furfur* were

significantly more common among patients with AD (Atopic dermatitis) than among patients with asthma or asymptomatic control subjects. Also, studies by Hedayati, *et al.*, (2009), found that 35% of the patients with AD and asthma showed specific higher levels of specific IgE against *A. alternate*. Another study was carried by Chowdary, *et al.*, (2003). He showed that the IgE levels were elevated in more than 90% of patients with allergic rhinitis. IgE values ranged from 2323 to more than 4000 IU/ml when the sino-nasal polyposis was associated with fungal elements (*i.e. Aspergillus* induced allergic rhinitis with sinusitis).

We sought to compare sensitization to fungi between patients with asthmatic and non-asthmatic (control group). The results for sera of patients with asthma disease were compared with non-asthmatic (control) sera for concentration of specific IgE antibody to *A. alternate*, *Aspergillus niger*, *A. repens*, *A. flavus*, *A. fumigatus*, *A. terreus*, *Fusarium solani*, *Penicillium glabrum*, *P. verrucosum*, *Rhizopus oryzae*, *Trichoderma viride*, *Candida albicans* and *Trichosporon cutaneum*. Mean specific IgE was higher in sera from patients with asthma for all antigens. Our results showed that statically there was a highly significant different in the concentrations of specific IgE levels between asthmatic and non-asthmatic patient's ( $P = 0.001$ ). Similarly, Hedayati, *et al.*, (2009), studied that the comparisons of serum total IgE level and specific IgE antibodies between asthmatic and non-asthmatic patients. He showed that the mean of total IgE and specific IgE level were higher in sera from patients with asthma than in non-asthmatic (control group). Serum total IgE in asthmatic patients and control group were recorded 172 and 44.5 IU/ml, respectively. Also, mean specific IgE level to *A. alternate* in asthmatic patients and control group were recorded 3.7 and 2 IU/ml, respectively.

## 5. Conclusion

In conclusion, the present study has demonstrated that there was a total of 13 fungal species isolated from household dusts. The most prevalent of these were *Aspergillus*, *Penicillium*, *Fusarium*, followed by *Trichoderma*. There is definite evidence of fungal sensitization in asthma. There is also a strong association between fungal sensitization and severity of asthma. A variety of fungi are known to cause sensitization in asthmatics. However, *Aspergillus* species seem to be the most important fungal agent causing sensitization and leading to severe asthma.

## Corresponding Author:

Dr. Mohamed A. Fareid  
Botany and Microbiology Department  
Faculty of Science, Al-Azhar University.  
Present address: Medical Microbiology Dept., Faculty of Medicine, H'ail University, SA.  
E-mail: [mohamedfareid73@yahoo.com](mailto:mohamedfareid73@yahoo.com)

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