Conference Paper

ORGANIC AEROSOLS AND THE DEVELOPMENT OF ALLERGIC DISORDERS

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The aim of this study was to investigate skin reactivity to organic dust extracts and total serum IgE and their relation to the prevalence of respiratory symptoms and ventilatory capacity in workers occupationally exposed to organic aerosols. It included workers employed in processing coffee, tea, dried fruits, spices, animal food, soy, hemp, cotton, swine farmers, and control groups of workers non-exposed to organic dust. All underwent a skin prick test (SPT) with water extracts of organic dust 1:10 w/v, *Dermatophagoides pteronyssinus,* mixed moulds, bacteria, histamin solution (1 mg/ml) and buffer solution. SPT was considered positive if the diameter of the observed wheal was 3 mm greater than that of buffer solution. The total IgE was measured by the PRIST method (Pharmacia Diagnostics AB, Upsala) and the values > 125 kU/L were considered increased. Data on respiratory symptoms were collected by standardized questionnaire. Ventilatory capacity was measured by recording MEFV curve. Airborne industrial dust were measured as total and respirable fraction. The exposed workers had a greater prevalence of positive SPT to organic dust extracts, except in soy processing. Increased IgE was found in workers processing coffee, tea, hemp, cotton and animal food, compared to non-exposed workers ($P<0.05$). Workers with positive SPT had a significantly higher total IgE. As there was no correlation between acute and chronic changes in ventilatory function, positive SPT, and level of total IgE, our findings could not predict objective respiratory impairment.

KEY WORDS: *occupational asthma, occupational exposure, organic dust, skin prick test, total serum IgE, ventilatory capacity*

Organic dust is a term related to the mixture of vegetable, animal, or microbial airborne particles which has always been a part of human environment. Industrial processing of organic materials and manipulation of large quantities of organic material in poorly ventilated indoor environment may lead to high levels of airborne organic dust (1). Organic dust is known to possess a variety of biological effects (Figure 1) (2). The reaction of the respiratory system to organic dust can be mediated by nonimmunologic (reflex, irritating, pharmacological) and immunologic (allergic hypersensitivity) mechanisms (3). Our earlier studies described organic aerosols as agents responsible for the development of respiratory impairment in exposed workers (4, 5). Workers exposed to such materials may often develop respiratory symptoms or diseases including rhinitis, conjunctivitis, chronic bronchitis, wheezing, bronchial hyperreactivity, and occupational asthma. Some of the organic aerosols have been shown to be potent sensitisers with positive skin tests to aqueous extracts of original organic dust, accompanied by increased serum IgE antibodies. These include dusts from coffee (6), tea and dried fruits (7), spices (8), soy-bean (9), swine hair (10), animal food (11), hemp (12), and cotton (13).

In this study, we compared the skin reactions to aqueous extracts of organic dust and total serum IgE levels with respiratory symptoms and ventilatory lung function in exposed and non-exposed workers.

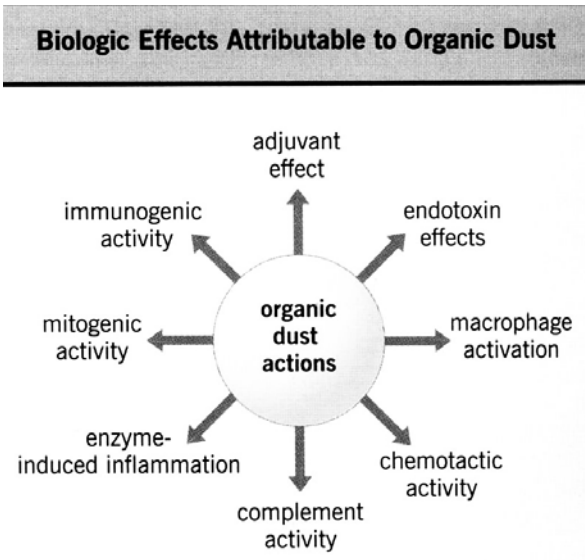

Figure 1 *Biologic effects attributable to organic dust (2)*

SUBJECTS AND METHODS

Subjects

A group of 292 workers employed in different industries processing coffee, tea and dried fruit, spices, soybean, animal food, hemp, cotton, and swine farmers was included in the study. In addition, a group of 288 non-exposed workers of similar age and duration of employment were also included in the study as controls. Sex, mean age and mean duration of exposure of all working groups are presented in Table 1.

Table 1 *Characteristics of examined workers*

Workers	Sex	Group	Number	Mean age (years)	Mean exposure (years)
Coffee	F	E	45	31	7
		C	34	32	6
Tea and dried fruits	F	E	50	34	7
		C	40	37	10
Spices	F	E	45	39	17
		C	45	37	16
Animal food	M	E	35	40	14
		C	31	42	12
Soy	M	E	19	31	4
		C	20	33	5
Swine farmers	M	E	32	35	8
		C	39	32	9
Hemp	F	E	42	40	16
		C	49	39	18
Cotton	F	E	24	26	5
		C	30	27	6

E = exposed; C = control; F = female; M = male

Skin prick testing

Skin prick tests were performed using a standardized method (14) with aqueous extracts of organic dust 1:10 w/v (Institute of Immunology, Zagreb) in exposed and control workers. Coffee workers were tested with green coffee, roasted coffee, and coffee dust collected while the workers emptied bags; tea workers were tested with sage, gruzyan, mentha, dog rose, Indian and chamomille; spice factory workers were tested with chilli pepper, paprika, celery, ginger, parsnip, onion, pepper and turmeric; soy bean workers were tested with raw soy and soy after the separation of oil and lecithin; animal food processing workers were tested with fish flour, carotene, corn, clover, sunflower, chicken meat, soy and yeast; hemp workers were tested with hemp from combing, carding, spinning, weaving, and softening machines; cotton workers were tested with cotton from carding and spinning machines, and cotton seed; swine farmers were tested with swine confinement agents, animal food, and swine hair. All workers were also tested with common inhalatory allergens: *Dermatophagoides pteronyssinus,* mixed moulds and mixed bacteria (Institute of Immunology, Zagreb). Histamine hydrochloride 1 mg/mL and buffer solution were tested as controls of positive and negative skin reactions. Skin prick test was considered positive if the wheal diameter was 3 mm or greater than the reaction to buffer solution (14).

Total IgE measurement

Serum levels of total IgE antibody were measured in exposed and control workers using PRIST (Pharmacia Diagnostics AB Uppsala Sweden), a direct radioimmunological sandwich technique based on paper discs as a solid phase. The levels of IgE below 125 IU/mL were considered normal.

Respiratory symptoms

Chronic respiratory symptoms were recorded using the British Medical Research Council Committee Questionnaire (15) with additional questions on occupational asthma (16). The following definition for occupational asthma was used: recurring episodes of dyspnoea, chest tightness and the obstructive type of pulmonary function impairment diagnosed by physical examination and spirometric measurements during exposure to dust at or following work. The workers were also asked additional questions about acute

symptoms experienced at work such as coughing, dyspnoea, dryness, secretion or bleeding of the nose, burning of the throat, lacrimation and headache.

Ventilatory capacity

Ventilatory capacity was measured in all workers by recording maximal expiratory flow volume (MEFV) using a portable flow-volume spirometer (Pneumoscreen, Jaeger, Würzburg, Germany) on Monday before (6 a.m.) and after (2 p.m.) the work shift. The measurements included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and maximum flow rates at 50 % and the last 25 % of the control vital capacity (FEF_{50}, FEF_{25}) . At least three MEFV curves were recorded and the best values were used for analysis. Pre-shift values of ventilatory parameters were compared with predicted normal values of Quanier (17).

Environmental measurement

Airborne industrial dust was sampled using a Hexhlet horizontal two-stage sampler in the working areas throughout the 8-hour work shift. Dust concentrations were expressed separately for the total and respirable dust fraction in mg/m^3.

Statistical analysis

The chi-square test (or Fisher's exact test, where appropriate) was used for testing differences in the number of positive skin tests, increased IgE values, and respiratory symptoms. The value of $P<0.05$ was considered statistically significant.

RESULTS

Skin testing

Figure 2 shows the frequency of positive skin tests in exposed workers and control workers. Positive skin tests were the most common in workers processing soy 15.8-100 % (in control workers 0-95 %) and the lowest in workers processing coffee 8.9-40 % (in control workers 0-14.7 %). It was also found that some extracts induced positive skin reaction in exposed workers, but not in non-exposed (green coffee, roasted coffee, soy lecithin) and that some extracts induced a similar positive response in the exposed and non-exposed workers (soy bean dust, dog rose, swine confinement agents). All tested workers had a positive skin reaction to histamine and none to buffer solution.

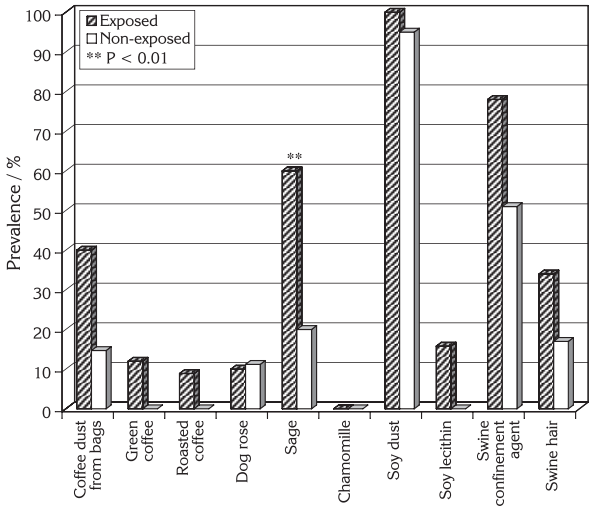

Figure 2 *Frequency of positive skin tests to different extracts of organic dust*

Figure 3 shows the frequency of positive skin tests in exposed workers to one or more tested organic dust extracts and to common inhalatory allergens, *Dermatophagoides pteronyssinus,* mixed bacteria and mixed moulds. Hemp processing workers showed the highest prevalence of positive skin reactions to extracts of relevant organic dust (64.2 %), but the lowest to *Dermatophagoides pteronyssinus* (2.5 %). None in this group had a positive skin reaction to bacteria and moulds. In cotton processing workers the prevalence of positive skin test was the same to tested extracts of relevant organic dust and to bacteria (33.3 %). The highest prevalence of positive skin reactions to *Dermatophagoides pteronyssinus* (28 %) and to moulds (10 %) was found in swine farmers.

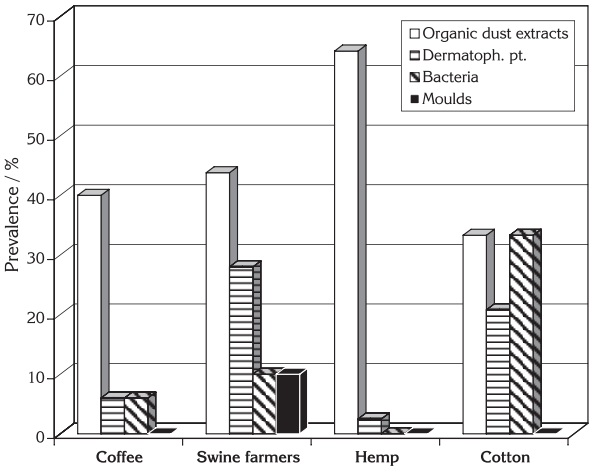

Figure 3 *Frequency of positive skin tests to organic dust extracts and common inhalatory allergens*

Table 2 *Relationship between the prevalence of respiratory symptoms and skin test results*

Groups	Skin test			Nasal catarrh		Chronic cough		Dyspnea		Occupational asthma	
	+/-	N	%	%	P	%	P	%	P	%	P
Coffee	+	11	24	40	<0.01	64	<0.05	46	n.s.	18	n.s.
N=45	-	34	76	20		32		38		6	
Tea and dried fruits	+	39	78	51	<0.01	18	n.s.	39	<0.01	0	n.s.
N=50	-	11	22	18		18		18		0	
Spices	+	33	73	36	n.s.	23	n.s.	16	<0.05	0	n.s.
N=45	-	12	27	41		41		50		0	
Soy	+	13	68	8	n.s.	39	<0.05	39	n.s.	15	n.s.
N=19	-	6	32	33		33		67		0	
Animal food	+	10	29	30	n.s.	50	n.s.	20	n.s.	20	n.s.
N=35	-	25	71	24		56		36		0	
Swine farmers	+	14	44	0	n.s.	50	n.s.	0	n.s.	14	n.s.
N=32	-	18	56	0		33		0		28	
Hemp	+	27	64	56	<0.01	48	n.s.	11	n.s.	22	<0.01
N=42	-	15	36	13		40		6		13	
Cotton	+	8	33	63	n.s.	63	n.s.	63	n.s.	25	n.s.
N=24	-	16	67	25		25		25		6	

n.s. = difference not statistically significant (P>0.05)

Respiratory symptoms

The prevalence of nasal catarrh was higher in coffee, tea and dried fruit, and hemp workers with positive skin tests than in those with negative skin tests to organic dust extracts (P<0.01). The prevalence of chronic cough was higher in coffee and soy bean workers with positive skin tests than in those with negative skin tests (P< 0.05) (Table 2).

The highest prevalence of occupational asthma in exposed workers with positive skin test to organic dust extracts was recorded in cotton workers (25 %). Coffee, soy bean, animal food, hemp, and cotton processing workers with positive skin tests had a higher prevalence of occupational asthma than those with negative skin tests, but this difference was statistically significant only for hemp workers (P<0.01). In contrast, swine farmers with negative skin tests had a higher prevalence of occupational asthma (27.8 %) than those with positive skin tests (14.3 %).

Ventilatory capacity

Ventilatory capacity in all groups of exposed workers showed reduction over the work shift. The pre-shift ventilatory capacity tests were lower than predicted values according to sex, age and height. However, there was no correlation between lung function tests and the skin reactions to organic dust extracts as well to total serum IgE levels.

Total IgE measurement

The largest number of exposed workers with increased serum total IgE levels was found in workers processing animal food (40.0%) and the lowest in swine farmers (9.4%). Significant differences in the prevalence of increased total serum IgE between exposed and non-exposed workers were found in workers processing coffee, animal food, tea and dried fruits, hemp, cotton (P<0.05), and spices (P<0.01) (Figure 4).

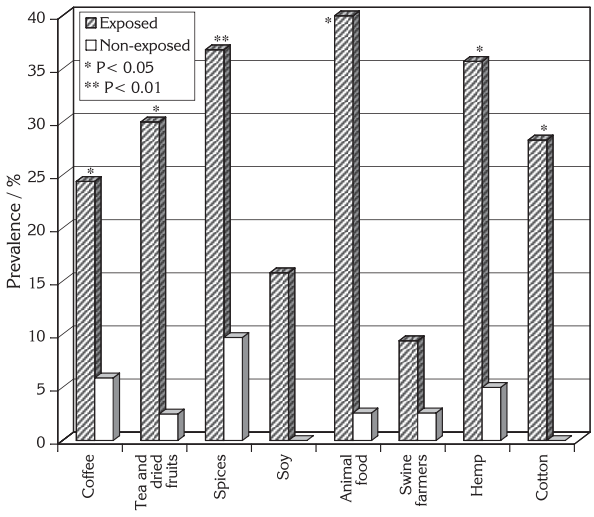

Figure 4 *Frequency of increased total serum IgE (>125 IU/L)*

Environmental dust measurements

Table 3 shows dust concentrations (total and respirabile) measured at workplaces, expressed as milligrams per cubic meter. The highest concentration of respirable dust was found in hemp processing, followed by soy bean, tea and dried fruits, animal food, cotton, swine farms, coffee, and spices.

Table 3 *Dust concentrations in the working areas of examined workers (mg/m^3)*

Working area	Total dust		Respirable fraction	
	Mean	Range	Mean	Range
Coffee	11.2	1.4 - 62.3	0.33	0.1 - 1.9
Tea and dreid fruits	16.7	5.3 - 24.9	3.2	1.0 - 5.4
Spices	2.9	0.5 - 10.1	0.05	0.1 - 2.1
Animal food	5.0	0.7 - 10.6	1.3	0.4 - 2.9
Soy	29.5	7.7 - 59.0	3.5	0.7 - 6.6
Swine farmers	8.2	1.5 - 18.4	0.5	0.1 - 3.2
Hemp	22.4	3.3 - 68.5	9.9	1.3 - 38.4
Cotton	3.7	1.5 - 7.2	1.0	0.7 - 1.4

DISCUSSION

Organic dust contains a multitude of plant (tanins, histamine, alkaloids, plicatic acid), animal (proteins, enzymes), and microbial (endotoxin, proteases, mycotoxins) agents with potential biologic effects. Several specific agents in organic dust such as proteins and enzymes can act as allergens (1). Epidemiologic and *in vitro* studies suggest that organic aerosols have considerable biological effect on airways and that exposure to them is associated with frequent respiratory symptoms, ventilatory capacity changes and immunologic reactions (5). Although IgE-mediated reactions are present in atopic subjects, all individuals are capable of mounting an IgE antibody response. So, persons with normal IgE can also occasionally respond to exposure to an occupational agent by producing specific IgE (18, 19). In epidemiological studies of workers exposed to inhalants, it is now common to determine an allergy using skin prick tests with common and occupational inhalant allergens and to measure total and/or specific IgE levels (14). Because many varieties of organic materials were present at the studied workplaces, we assumed that these materials would contain allergens. There was a difference in the prevalence of positive skin tests to tested organic extracts between the exposed groups of workers. However, non-exposed controls also exhibited a high prevalence of positive skin tests, suggesting that many of these reactions are nonspecific and not immunologic.

Nevertheless, increased serum IgE levels in the large number of our exposed workers in comparison with controls suggest that sensitisation might be responsible for the development of respiratory symptoms. The prevalence of increased total serum IgE values varied in the exposed groups of workers from 2.5 % to 40 %. Most workers with the increased IgE serum levels worked in processing animal food (40 %) and spices (36.8 %). On the basis of positive skin reactions to organic dust allergens, we can only speculate on possible aetiological relationship between organic dust allergens and specific sensitivity of the respiratory system (5). Skin tests provide some indication of sensitivity, but not always of sensitisation in the lung. We studied the specific bronchial reactivity to herbal tea extracts and non-specific bronchial reactivity to metacholine in healthy subject not previously exposed to tea dust. Skin reactivity to tea dust extracts did not correlate with the type and degree of airway reaction to tea dust extracts, suggesting that skin reactivity is not a good predictor of airway reactivity (20). Bronchial provocation tests with organic extracts are the additional tests which can confirm sensitisation and also demonstrate a relevant clinical expression. We performed a specific bronchial provocation test with green coffee extract in four workers who had positive skin prick test to extract and increased value of total IgE which varied from 225 - 750 IU/L (21). This testing showed an early-phase bronchial reaction and considerable decrease in ventilatory capacity in the examined workers.

Coffee, soy bean, animal food, hemp, and cotton processing workers with positive skin tests to organic dust extracts had a higher prevalence of occupational asthma than those with negative skin tests (Table 2). This is in contrast with swine farmers with negative skin tests who showed higher prevalence of occupational asthma (28 %) than those with positive skin tests (14 %). The discrepancy in the prevalence of occupational asthma and positive skin reaction in swine farmers suggests that non-immunologic mechanisms are involved in the aetiology of occupational asthma in this occupation (22).

Organic dust caused bronchoconstriction in a large proportion of industrial workers. This was more evident in the changes in FEF_{50} and FEF_{25} than in FEV_1 or FVC (5). Across-shift reductions, particularly

those involving flow rates at low lung volumes, were more pronounced in workers with positive than in those with negative skin tests. However, no consistent relationship was found between the severity of across-shift changes in lung function and immunologic markers (skin tests or serum IgE levels). The comparison of the pre-shift ventilatory capacity data with predicted normal values has shown that occupational exposure to these organic dusts may cause chronic lung function impairment. There was, however, no relationship established between decreased baseline pulmonary function and positive skin tests or increased IgE values (5).

CONCLUSION

Workers exposed to organic dust had positive skin tests to organic dust extracts more frequently than controls, except for soy bean workers. The prevalence of workers with increased values of total serum IgE was significantly higher in groups of exposed than in non-exposed.

There was no correlation between skin reactivity to organic dust extracts and total IgE values, and acute or chronic lung function changes, e.g. these immunologic findings can not predict a respiratory impairment. The clinical relevance of a positive skin test to organic dust and increased total IgE value should be individually evaluated by the additional diagnostic procedures.

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Sažetak

ULOGA ORGANSKIH AEROSOLA U NASTANKU ALERGIJSKIH POREMEĆAJA

U radnika profesionalno izloženih organskim aerosolima ispitana je kožna reaktivnost na ekstrakte organskih prašina i razina ukupnog serumskog IgE te njihova povezanost s respiratornim simptomima i ventilacijskim kapacitetom pluća.

U ispitivanje su uključeni radnici u proizvodnji kave, čajeva i suhog voća, začina, stočne hrane, u preradi soje, konoplje, pamuka, na svinjogojskoj farmi te kontrolna skupina radnika koji nisu profesionalno izloženi organskoj prašini. U svih radnika učinjen je *prick* kožni test (PKT) s vodenim ekstraktima organskih prašina (1:10 w/v), alergenskim pripravkom *Dermatophagoides pteronissynus,* grupnim alergenima plijesni i bakterija te histamin hidrokloridom 1 mg/mL i puferskom otopinom (Imunološki zavod u Zagrebu). Pozitivnim PKT-om smatrana je urtika promjera 3 mm i više od reakcije na pufersku otopinu. Ukupni IgE u serumu izmjeren je PRIST-metodom (Pharmacia Diagnostic AB Uppsala, Švedska). Vrijednosti >125 IU/L smatrane su povišenima. Podaci o respiratornim simptomima prikupljeni su standardiziranim upitnikom. Ventilacijski kapacitet pluća izmjeren je registracijom MEFV-krivulje. Zaprašenost na radnim mjestima izmjerena je kao totalna i respirabilna frakcija.

Eksponirani radnici u odnosu na neeksponirane imaju veću učestalost pozitivnog PKT-a na testirane organske prašine, osim u radnika u preradi soje. Značajno je više osoba s povišenim IgE u radnika na preradi kave, čajeva, konoplje, pamuka i stočne hrane nego u neeksponiranih. Radnici s pozitivnim PKT-om u odnosu na radnike s negativnim PKT-om imaju višu razinu ukupnog IgE i veću prevalenciju nekih respiratornih simptoma, ali razlika nije uvijek statistički značajna. Nije utvrđena korelacija između akutnih i kroničnih promjena ventilacijske funkcije pluća i pozitivne kožne reakcije na ekstrakte organskih prašina te razine ukupnog IgE.

U zaključku se ističe da eksponirani radnici u odnosu na neeksponirane imaju značajno veću učestalost nekih pokazatelja senzibilizacije na organske prašine (pozitivan PKT, povišen IgE, pozitivni dišni simptomi). Nije potvrđena povezanost tih pokazatelja s promjenama ventilacijske funkcije pluća, tj. njihovo značenje kao pokazatelja respiratornog oštećenja. Kliničko značenje pokazatelja senzibilizacije na organske prašine treba individualno evaluirati dodatnim dijagnostičkim postupcima.

KLJUČNE RIJEČI: *organska prašina,* prick *kožni test, profesionalna astma, profesionalna ekspozicija, ukupni serumski IgE, ventilacijski kapacitet pluća*

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