

Brief Report

Exposure to Bioaerosols: Allergic Reactions and Respiratory Function in Polish Hop Growers

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Background The aim of the study was to assess the prevalence of work-related symptoms in hop growers and their relation to bioaerosols exposure. The study group comprised 69 hop growers and 58 office workers as controls. The examination included: physician-administrated questionnaire, PEF measurements, skin prick test, agar-gel precipitation test, and migration inhibition test. Microbiological air sampling was performed on all farms.

Results The concentrations of total airborne microflora ranged from 2.08 to 129.6×10^3 CFU/m³. Airborne endotoxin and dust concentrations ranged from 26 to 6250 ng/m³ and 0.2–31.7 mg/m³, respectively. Altogether 52.2% of farmers complained of work-related symptoms. Positive skin reactions to microbial allergens were significantly more frequent in a group of hop growers with work-related respiratory symptoms compared to the rest of the farmers (18% vs 2%, $P < 0.05$). Positive reactions in agar-gel precipitation test and in the leukocyte migration inhibition test were not correlated with the occurrence of work-related symptoms. The mean daily PEF values in farmers were lower compared to controls (469.7 ± 127.5 vs 562.9 ± 123.8 ; $P < 0.001$). PEF (amp%mean) was higher in farmers compared to controls (9.3% vs 8.1%; $P < 0.05$).

Conclusion Despite relatively lower exposure to bioaerosols, compared to farmers in other branches of agriculture, over 50% of hop growers complained of work-related symptoms. This may be partly due to the effects of microbial allergens and toxins and partly to the irritant or allergic properties of hop plant itself. Am. J. Ind. Med. 46:371–374, 2004. © 2004 Wiley-Liss, Inc.

KEY WORDS: hop (*Humulus lupulus*); farmers; organic dust; sensitization; work-related

BACKGROUND

Hop (*Humulus lupulus*) is a perennial herbaceous liana of the family Cannabinaceae, cultivated extensively in Germany, Czech, Poland, Great Britain, and USA. The female inflorescences of the plant (cones) are commonly used as a flavoring and preservative agent in brewery. There have been a few case reports suggesting that hops may have allergic or irritant activity [Newmark, 1978; Godnic-Cvar et al., 1999; Śpiwak and Dutkiewicz, 2002].

Newmark [1978, 1979] presented two cases of work-related respiratory diseases due to the exposure to hop

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TABLE I. Antigens Used for Testing

	SPT ^a	Precipitins	MIF ^b
<i>Acinetobacter calcoaceticus</i>		+	
<i>Pantoea agglomerans</i>	+	+	+
<i>Arthrobacter globiformis</i>		+	+
<i>Bacillus subtilis</i>		+	
<i>Saccharopolyspora rectivirgula</i>	+	+	+
<i>Streptomyces albus</i>	+	+	
<i>Thermoactinomyces vulgaris</i>		+	
<i>Alternaria alternata</i>		+	
<i>Aspergillus fumigatus</i>	+	+	+
<i>Cladosporium epiphyllum</i>		+	
<i>Penicillium citrinum</i>		+	
Hop extracts	+	+	

^aSPT-skin prick tests.^bTest for inhibition of leukocyte migration in the presence of specific antigen.

dust. Until now, little is known about the exposure of hop farmers to dust and bioaerosols and their impact on health [Aleksandrov and Gyeorgiev, 1977].

The aim of our study was to assess the prevalence of work-related symptoms in Polish hop growers and their relation to organic dust and endotoxin exposure.

METHODS

Air samples for determination of the concentrations of airborne microorganisms, dust, and endotoxin were collected on 19 hop farms. A group of 69 hop growers (aged 17–84, median 48 years) and 58 office workers (aged 17–65, median 45.5 years) as a control group underwent clinical examination which included a physician-administered questionnaire on the occurrence of work-related symptoms and a physical examination. Clinical tests comprised: skin prick test and agar-gel precipitation test with environmental microbial antigens and hop extracts, and test for inhibition of leukocyte migration in the presence of specific antigens (MIF) with four microbial antigens. Antigens used for testing are presented in Table I. The concentrations of IL-6, IL-8, TNF- α in blood serum were determined by Elisa test (Pharmingen, San

Diego, California). Peak flow measurements were performed using a “Personal Best” peak flow meter.

RESULTS

Total concentrations of airborne microorganisms were within a range of $2.08\text{--}129.6 \times 10^3$ CFU/m³ (median 9.2×10^3 CFU/m³). Gram-positive bacteria were dominant in the air of most of the farms, comprising 22.2–96% of the total count. Among them prevailed corynebacteria and bacilli. Fungi constituted 3.7–65.4% of the total count and the dominant species were *Penicillium citrinum*, *Alternaria alternata*, and *Cladosporium epiphyllum*. Thermophilic actinomycetes and Gram-negative bacteria were detected in the air of only 10 and 6 farms, respectively.

Airborne dust concentrations at the workplace ranged from 0.2 to 31.7 mg/m³ (median 3.3 mg/m³). The concentrations of airborne endotoxin were in the range of 26–6,250 ng/m³ (median 52.2 ng/m³).

Table II presents the demographic characteristics of the studied population. On clinical examination, 36 out of 69 hop growers (52.2%) complained of work-related symptoms. These included respiratory symptoms reported by 27 farmers

TABLE II. Demographic Characteristic of the Study Groups

	Hop growers (n = 69)	Control group (n = 58)
Age (years) median (range)	48 (17–84)	45.5 (17–65)
Exposure to Hop dust (years) median (range)	26 (3–53)	—
Men n (%)	37 (53.6%)	35 (60.3%)
Non-smokers n (%)	29 (42%)	20 (34.5%)
Ex-smokers n (%)	16 (23.2%)	11 (18.9%)
Smokers n (%)	24 (34.8%)	27 (46.5%)

TABLE III. Concentration of Cytokines in Blood Serum of Hop Growers and Controls

	Hop growers median (range)	Control group median (range)
Interleukin-6 (pg/ml)	1.3 (0–15.2)	1.0 (0–28.8)
Interleukin-8 (pg/ml)	12.2 (1.7–245.9)	10.5 (0.8–208.2)
TNF- α (pg/ml)	0.7 (0–24.9)	0.35 (0–118.8)

(39%), mucous and skin irritation by 23 (33.3%), and general symptoms by 18 (26.1%). Among respiratory symptoms prevailed cough reported by (24.6%) farmers, chest tightness by (23.2%) farmers, chest pain by (15.9%) farmers, and wheezing by (10.1%) farmers. There was no statistically significant association between prevalence of symptoms and the length of exposure to hop dust or smoking status.

Positive skin prick reactions were recorded in 8 (11.6%) farmers (all of them complained of work-related symptoms) and in 2 controls (3.4%). Positive skin tests to microbial allergens were significantly more frequent in a group of hop growers with work-related respiratory symptoms compared to the rest of the farmers (18 vs. 2%, $P < 0.05$). Positive reactions in agar-gel precipitation test occurred significantly more frequently among farmers compared to controls (65.2 vs. 31.0%, $P < 0.001$) but were not correlated with the occurrence of work-related symptoms. Twelve of 69 farmers (17.4%) revealed positive reactions in the leukocyte migration inhibition test while none of the controls showed positive response ($P < 0.01$). Positive reactions to environmental microbial antigens occurred in 8 out of 36 symptomatic workers and in 4 out of 33 asymptomatic ones ($P > 0.05$).

There were no significant differences in cytokine concentrations between study group and controls (Table III). However, there was a positive correlation between exposure to airborne endotoxin and IL-6 level in farmers' serum (Spearman test: $r = 0.364$, $P < 0.01$).

The mean daily PEF values in farmers were significantly lower compared to controls (469.7 ± 127.5 vs 562.9 ± 123.8 ; $P < 0.001$; the data were adjusted for gender, height, and smoking). PEF daily variability (amp%mean) was higher in farmers compared to controls (9.3 vs. 8.1%; $P < 0.05$).

DISCUSSION

The results of our study indicate that exposure to bioaerosols on hop-processing farms is much lower compared to other agricultural branches such as: herb or flax processing [Dutkiewicz, 1986; Dutkiewicz, 1997], grain handling [Swan and Crook, 1998; Dutkiewicz et al., 2000], poultry farming [Radon et al., 2002], cattle-breeding [Radon et al., 1999], or pig-raising [Mackiewicz, 1998]. Despite that fact, the reported concentrations of microorganisms and endotoxins exceeded the values proposed by some authors as the Occu-

pational Exposure Limit (OEL) [Clark, 1986; Dutkiewicz and Jabłoński, 1989; Malmros et al., 1992]. Our findings are in line with the results reported by Aleksandrov and Gyeorgyev [1977], who carried out their study in the Russian hop processing facilities. The authors suggested that the low degree of microbial contamination might be due to antimicrobial properties of hop. This explanation is in agreement with more recent studies conducted by Langezaal et al. [1992], who demonstrated that hop extract reveals strong antimicrobial properties against some Gram-positive bacteria and fungi.

Despite relatively low exposure to bioaerosols reported in the present study, the prevalence of work-related symptoms among examined hop growers was in the same range as among pig farmers [Mackiewicz, 1998] or grain handling farmers [Skórska et al., 1998] but lower than among herb processing workers [Dutkiewicz et al., 2001]. The structure of reported symptoms in all cited studies was similar (prevailed respiratory symptoms, followed by mucous and skin irritations). In our study we did not observe the positive correlations between the occurrence of work-related symptoms and the concentrations of airborne dust, endotoxin and microorganisms.

The frequency of positive skin reactions in a group of examined hop growers was much lower compared to those found earlier in the groups of workers employed in other farm environments [Mackiewicz, 1998; Skórska et al., 1998; Dutkiewicz et al., 2001]. In our study we found an association between positive skin reactions to tested allergens and the occurrence of work-related symptoms. Moreover, positive reactions to microbial allergens were significantly more frequent in a group of farmers with respiratory symptoms compared to those without symptoms. Although this may suggest that IgE mediated immunological reaction may play some role in evoking work-related symptoms in hop growers, the conclusion must be drawn with care because of small numbers of reactive farmers. The frequencies of positive reactions found in agar-gel precipitation test and the leukocyte migration inhibition test were significantly higher in the group that compared to controls. However, no such relation could be found between groups of symptomatic and asymptomatic farmers, which suggests that neither precipitin-mediated nor late cellular reaction play an important role in etiology of work-related symptoms in hop growers. Probably, positive reactions found in both tests reflect rather

environmental exposure to allergens than clinical symptoms. This is in agreement with the results reported by Park et al. [1999], who found specific IgG (sIgG) in the serum of almost all workers exposed to grain dust, but did not notice any relation between the respiratory symptoms and the presence of sIgG.

In our study, we have not been able to find a correlation between the occurrence of work-related respiratory symptoms and changes in lung function. However, the mean daily PEF values and PEF daily variability (amp%mean) in farmers were significantly lower compared to controls.

All these facts may suggest that prolonged exposure to even low concentrations of bioaerosols in the work environment may evoke work-related symptoms and impairment of lung function. Most probably, in the etiopathogenesis of work-related disorders in hop growers, not only specific allergic reactions (mainly IgE mediated) are involved but also non-specific reactions to constituents of microbial cell wall or hop plant products. This problem however, needs further study.

CONCLUSION

Despite relatively lower exposure to bioaerosols, compared to farmers in other branches of agriculture, over 50% of hop growers complained of work-related symptoms. This may be partly due to the effects of microbial allergens and toxins and partly to the irritant or allergic properties of the hop plant itself. Nevertheless, this problem needs further study.

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