

## THE EFFECTS OF EXPOSURE TO ORGANIC DUST ON THE RESPIRATORY SYSTEM OF POTATO PROCESSING WORKERS

Janusz Milanowski<sup>1</sup>, Anna Góra<sup>2</sup>, Czesława Skórska<sup>2</sup>, Barbara Mackiewicz<sup>1</sup>, Ewa Krysińska-Traczyk<sup>2</sup>, Grażyna Cholewa<sup>2</sup>, Jolanta Sitkowska<sup>2</sup>, Jacek Dutkiewicz<sup>2</sup>

<sup>1</sup>Clinic of Lung Diseases, Medical Academy, Lublin, Poland

<sup>2</sup>Department of Occupational Biohazards, Institute of Agricultural Medicine, Lublin, Poland

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**Abstract:** A cross-sectional study was carried out to evaluate lung function and the prevalence of work-related symptoms in workers of a potato processing plant located in Lublin region (eastern Poland). The study group comprised 61 workers employed in 2 departments. The examination included: physician-administrated questionnaire on occurrence of work-related symptoms, occupational history and smoking habits. Spirometry was performed before (7:00–8:00) and after (16:00–17:00) the morning shift. Altogether 41/61 (67.2%) subjects reported at least one symptom associated with their job. Pulmonary symptoms were recorded in 28/61 (45.9%) subjects. The most commonly recorded complaints were: cough (44.3%), hoarseness (19.7%), shortness of breath (18%), followed by headache and skin lesion (13.1% each), and eye and nose irritation (11.5%). The prevalence of work-related symptoms (except for eye and nose irritation) was higher in the group of subjects working longer than 4 years (the difference was statistically significant only for skin lesion). Among non-smoking workers a significantly higher prevalence of headache was seen compared to smokers (Fisher's test,  $p < 0.05$ ). Smokers complained more frequently of respiratory symptoms such as cough, shortness of breath, hoarseness and chest pain. The difference was significant only for cough ( $p < 0.05$ ). A statistically significant over-shift decline in all measured spirometric values: FVC, FEV<sub>1</sub> ( $p < 0.001$ ), FEV<sub>1</sub>/VC ( $p < 0.05$ ), PEF ( $p < 0.01$ ) was observed.

**Address for correspondence:** Prof. Janusz Milanowski, MD, Clinic of Lung Diseases, Medical Academy, Jaczewskiego 8, 20-090 Lublin, Poland.

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### INTRODUCTION

Results of epidemiological studies indicate that workers employed in the agricultural crops processing industry have an increased risk of suffering from work-related symptoms [4, 11, 15, 18, 20, 30, 33, 34]. This is mainly due to the exposure to high concentrations of organic dust comprising bacteria and their degradations products, fungi and the substances of plant or animal origin (pollen, animal dander) [3, 5, 7, 12, 18, 22, 31]. It is widely recognized that inhalation of such a large variety of

antigens may lead to development of skin, eye and nose symptoms, asthma, allergic alveolitis, various chronic respiratory symptoms [4, 6, 10, 13, 21, 26, 27, 30, 34], and lung function decrement [18, 29, 32, 34].

Zuskin *et al.* [34] found a high prevalence of chronic respiratory symptoms among poultry food processing workers. Rosenman *et al.* [20] described a case of occupational asthma in a 33-year-old man employed in the sugar beet processing industry. During the work, patient experienced episodes of dry cough, shortness of breath, sharp chest pains, sore throat and fatigue. Positive

**Table 1.** Demographic characteristics of potato processing workers by job category.

	Department P (N = 35)	Department S (N = 26)	Total (N = 61)
Age median (range)	43 (20-65)	41.5 (23-67)	43 (20-67)
Years of employment median (range)	3 (1-24)	5 (1-36)	4 (1-36)
> 4 years	16 (45.7%)	16 (61.5%)	32 (52.4%)
Male N (%)	21 (60%)	23 (88.5%)	44 (72.1%)
Female N (%)	14 (40%)	3 (11.5%)	17 (27.9%)
Smokers N (%)	19 (54.3%)	13 (50%)	29 (47.5%)
Non-smokers N (%)	16 (45.7%)	13 (50%)	32 (52.5%)

skin test, the presence of IgG against *A. niger* and positive bronchoprovocation test to mouldy sugar beet pulp supported a casual association [20]. Studies carried out in grain processing and animal feed industry showed a decline in lung function among workers related to the concentration of dust and endotoxin [18].

Similar disorders were also found among potato processing workers.

Greene and Bannan [9] presented 2 cases of hypersensitivity pneumonitis in potato riddlers who were sorting and sieving potatoes after storage in a pit covered with hay. In both cases antibodies to *Micropolyspora faeni* were detected.

Ewers and Tapp [6] revealed a very high prevalence of eyes, nose and respiratory symptoms among workers employed in the potato processing industry. Data presented by these authors were in line with the results of studies conducted by Hollander *et al.* [11] and later Zock *et al.* [30] in the Dutch potato industry.

In another study [28], Zock and co-workers also demonstrated a strong humoral immune response (elevated IgG level, mostly of IgG<sub>4</sub> subclass) directed mainly to potato antigens. This response, however, was of no relevance for the occurrence of respiratory symptoms. None of examined workers had specific IgE antibodies. Authors concluded that allergic reactions of type I and III are unlikely to play a role in etiology of work-related respiratory symptoms among potato processing workers [28].

Nethertheless, allergic reactions (mostly of type I) due to contact with potato proteins themselves were previously reported [2, 16, 23]. There were several incidents of bronchial asthma, rhinoconjunctivitis, contact urticaria and angioedema described in subjects (mostly housewives) peeling raw potatoes [8, 13, 17, 19].

Beausolein and co-workers [1] described a 4-year-old child who rapidly developed anaphylactic reaction, including urticaria, angioedema, respiratory distress, vomiting and diarrhea after biting a raw potato. Skin prick test with fresh potato was positive.

Some authors underline the role of inorganic compounds such as silica from soil as causative agents of

**Table 2.** Frequency of work-related symptoms reported by potato processing workers employed in different departments.

	Workers reporting symptoms n (%)		
	Department P	Department S	Total
Cough	16 (45.7%)	11 (42.3%)	27 (44.3%)
Shortness of breath	8 (22.6%)	3 (11.5%)	11 (18%)
Chest pain	1 (2.9%)	4 (15.4%)	5 (8.2%)
Total pulmonary symptoms	17 (48.6%)	11 (42.3%)	28 (45.9%)
Headache	4 (11.4%)	4 (15.4%)	8 (13.1%)
Temperature	2 (5.7%)	0 (0%)	2 (3.3%)
Total general symptoms	6 (17.1%)	4 (15.4%)	10 (16.4%)
Hoarseness	8 (22.9%)	4 (15.4%)	12 (19.7%)
Conjunctivitis	6 (17.1%)	1 (3.8%)	7 (11.5%)
Rhinitis	6 (17.1%)	1 (3.8%)	7 (11.5%)
Skin Lesion	2 (5.7%)	6 (23.1%)	8 (13.1%)
Total	24 (68.6%)	17 (65.4%)	41 (67.2%)

work-related symptoms. Jorna *et al.* [14] investigated the occurrence of pneumoconiosis and airflow limitation in a group of 172 potato sorters exposed to inorganic dust, high in diatomaceous earth. Results of this study demonstrated a decrease in lung function parameters indicating airflow obstruction, dose-related to dust exposure. However, no radiological or biochemical (elevated level of type III procollagen) evidence of fibrosis was observed.

The objective of our cross-sectional study was to evaluate lung function and the prevalence of work-related symptoms in a group of potato processing workers in Lublin region.

## MATERIALS AND METHODS

The study was carried out in a large potato processing facility located in Lublin region (eastern Poland). The workers were employed in 2 main production departments: potato meal and flakes producing department (department P) and potato syrup producing department (department S). The primary tasks performed in the first processing area were: unloading potato tubers from trucks (outside the building), washing and peeling, manual trimming of black spots, machine cutting peeled potatoes into small cubes, blanching, drying, and finally milling obtained flakes and packing potato meal. Workers employed in the second department were involved in pouring and then mixing of potato starch (starch imported from the Netherlands) and corn starch for syrup, pouring water to obtain starch mixture, and finally after fermentation, pouring the prepared syrup into barrels for preservation until dispatch for sale.

**Table 3.** Prevalence of work-related symptoms reported by potato processing workers with respect to duration of employment and smoking habit.

	Smoking		Duration of employment	
	Smokers N = 29 (%)	Non-smokers N = 32 (%)	< 4 N = 29 (%)	≥ 4 N = 32 (%)
Age median (range)	43 (24-60)	40 (20-67)	39 (20-67)	43 (24-62)
Cough	17 (58.6%)*	10 (31.25%)	11 (37.9%)	16 (50%)
Shortness of breath	6 (20.7%)	5 (15.6%)	4 (13.8%)	7 (21.9%)
Chest pain	3 (10.3%)	2 (6.25%)	1 (3.4%)	4 (12.5%)
Headache	1 (3.5%) <sup>†</sup>	7 (21.9%)	4 (13.8%)	4 (12.5%)
Temperature	2 (6.9%)	0 (0%)	1 (3.4%)	1 (3.4%)
Hoarseness	8 (27.6%)	4 (12.5%)	6 (20.7%)	6 (20.7%)
Conjunctivitis	2 (6.9%)	5 (15.6%)	4 (13.8%)	3 (9.4%)
Rhinitis	2 (6.9%)	5 (15.6%)	4 (13.8%)	3 (9.4%)
Skin lesion	3 (10.3%)	5 (15.6%)	1 (3.4%)	7 (21.9%) <sup>‡</sup>
Total	19 (65.5%)	22 (68.8%)	18 (61.1%)	23 (71.9%)

\*p < 0.05 smoking potato processing workers vs. non-smoking subjects; <sup>†</sup>p < 0.05 (Fisher's test) smoking potato processing workers vs. non-smoking subjects; <sup>‡</sup>p < 0.05 (Fisher's test) workers employed < 4 years in potato processing industry vs. subjects working ≥ 4 years in potato processing industry.

**Table 4.** Pre- and Post- shift lung function among potato processing workers.

	FVC (l) Mean ± SD	FEV <sub>1</sub> (l) Mean ± SD	FEV <sub>1</sub> /VC (%) Mean ± SD	PEF (l/s) Mean ± SD
Pre-shift	3.33 ± 0.98 <sup>***</sup>	2.70 ± 0.93 <sup>***</sup>	82.08 ± 13.13*	5.76 ± 2.14 <sup>**</sup>
Post-shift	2.97 ± 0.93	2.42 ± 0.95	78.31 ± 17.26	5.09 ± 2.24

<sup>\*\*\*</sup>p < 0.001 spirometric values pre-shift vs. post shift; <sup>\*\*</sup>p < 0.01 spirometric values pre-shift vs. post shift; \*p < 0.05 spirometric values pre-shift vs. post shift.

**Study population.** In our study, 61 workers directly involved in the production process were enrolled. Of these, 35 were engaged in production of potato flakes and meal (department P) and 26 in production of potato syrup (department S).

All subjects gave formal consent to participate in the study. The Ethics Commission of the Institute of Agricultural Medicine approved human subjects protocols.

**Medical examination.** During the morning shift, all workers were interviewed with a physician-administrated questionnaire on occurrence of work-related symptoms (including: cough, shortness of breath, chest pain, headache, general malaise, skin lesion, conjunctivitis, rhinitis), occupational history, and smoking habits. The nature of auscultatory phenomenon over lung fields was evaluated by a fully qualified physician. Next, 45 out of 61 participants were subjected to pulmonary function examinations with use of a Vitalograph spirometer. The tests were performed before (07:00–08:00 am) and after (16:00–17:00) the morning shift.

Forced expiratory volume in the first second (FEV<sub>1</sub>), forced vital capacity (FVC) and peak expiratory volume (PEF) were recorded. The over-shift changes in spirometric values were calculated as pre-shift – post-shift. The

changes in volume were divided by FEV<sub>1</sub> max or FVC max and reported as percentage change (% FEV<sub>1</sub> change, % FVC change).

**Statistical analysis.** Chi-square test, or when appropriate Fisher's exact test, were used for comparison of categorical variables. For comparison of continuous variables, Student's t-tests were performed. P < 0.05 was regarded as a level of significance.

Most of the study was conducted during the years 1989–1991 and continued during 1999–2002.

## RESULTS

Demographics of the study population is shown in Table 1.

The group of 61 examined workers comprised 44 men and 17 women aged 20–67 (median 43) years, with duration of employment ranging from 1–36 years (median 4 years). Of all workers (N = 61), 29 (47.5%) were current smokers and 32 (52.5%) were non-smokers.

The prevalence of work-related symptoms in potato processing workers is presented in Table 2. Altogether, 41/61 (67.2%) subjects reported at least one health problem associated with their job. Those most commonly recorded

were cough (44.3%), hoarseness (19.7%), shortness of breath (18%), followed by headache and skin lesion (13.1% each), and eye and nose irritation (11.5%). Other symptoms occurred less frequently. Among 41 symptomatic workers, 24 (58.6%) reported more than one symptom.

Analysis of the prevalence of work-related complaints by job category demonstrated that workers employed in the potato meal producing department (department P) reported more frequently occurrence of cough, shortness of breath, hoarseness and eye and nose irritation than subjects working in the syrup producing department (respectively: 45.7% vs. 42.3%; 22.6% vs. 11.5%; 22.9% vs. 15.4%; 17.1% vs. 3.8%).

Skin problems occurred more frequently in department S (23.1% vs. 5.7%; Fisher's test:  $p = 0.054$ ). The difference was not statistically significant.

As shown in Table 3, the prevalence of symptoms associated with work (except for eye and nose irritation) was higher in the group of subjects working for longer than 4 years. However, the difference was statistically significant only for skin lesion.

Among non-smoking workers a significantly higher prevalence of headache was seen compared to smokers (Fisher's test,  $p < 0.05$ ). Smokers complained more frequently of respiratory symptoms such as cough, shortness of breath, hoarseness and chest pain. The difference was significant only for cough ( $p < 0.05$ ).

Physical examination by auscultation found wheezing and dry rales in 3 workers (4.9%), dry rales alone in 1 worker (1.6%) and inspiratory crackles in 2 workers (3.3%). In 55 (90.2%) subjects the results of physical examination were normal.

Table 4 presents the outcome of respiratory function tests performed in 45/61 examined potato processing workers. Analysis of over-shift changes in lung function demonstrated a statistically significant decline in all measured spirometric values: FVC, FEV<sub>1</sub> ( $p < 0.001$ ), FEV<sub>1</sub>/VC ( $p < 0.05$ ), PEF ( $p < 0.01$ ). Among smoking workers the lower spirometric values (both baseline and post shift) were observed compared to non-smokers. The same tendency was recorded in subjects working over 4 years. The differences were not statistically significant. There were no differences in results of lung function test between subgroups of workers employed in different departments.

The over-shift percentage changes (% FVC change, % FEV<sub>1</sub> change) were lower in smokers compared to non-smokers (respectively 9.3% vs. 10.3% and 8% vs. 11.6%) and among workers over 40 years of age compared to the younger group (% FEV<sub>1</sub> change 8.7% vs. 11.5%)

The differences were not statistically significant.

## DISCUSSION

Handling raw potatoes could be associated with exposure to high concentration of endotoxin, airborne microorganisms [5, 12, 31] and multiple proteins derived from potatoes themselves [13, 16, 19, 23]. Inhalation of those agents induce intense allergic, irritant or non-

specific inflammatory reactions and in result lead to development of work-related respiratory and general symptoms [6, 11, 21, 30].

The results of the present study show a high prevalence of work-related complaints among workers employed in the potato processing industry. Altogether, 41/61 (67.2%) examined subjects reported at least one symptom. The prevalence rate was similar to those observed in Polish farmers exposed to flax dust (62.7%) [25] and grain dust (44.7%) [24], but lower than the rate observed in herb processing workers (76.5%) [4].

On average, symptoms occurred after 4.6 years of exposure (mean, range 1–25 years). This fact may explain the higher prevalence of work-related problems among subjects employed for over 4 years.

The frequency of pulmonary problems revealed in the present study was lower than that presented by Ewers and Tapp [6] in a group of American potato processing workers, but higher than the prevalence reported by Dutch authors [11, 30, 33].

The detailed analysis of the structure of reported symptoms indicated that coughing (44.3%), hoarseness (19.7%) and shortness of breath (18%) were the most common complaints among examined workers. This group of complaints occurred more frequently (though not significantly) among workers employed in potato flakes and meal producing department (department P), compared to the workers involved in production of potato syrup (department S). It is noteworthy that coughing and hoarseness are quite non-specific symptoms and may reflect acute irritation, non-specific inflammation as well as allergic reaction to bioaerosols. The data presented by Hollander *et al.* [11] and Zock *et al.* [28, 33] suggest that respiratory problems occurring in potato processing workers are most likely caused by non-specific inflammation related to endotoxin exposure.

In our study, the concentration of airborne endotoxin detected in department P was much higher than in the syrup producing division (at some working sites this ranged from 45.5–1893.9  $\mu\text{g}/\text{m}^3$ ) [3]. Therefore we concluded that endotoxin may partly account for the increased prevalence of respiratory symptoms among workers of department P.

Another of our findings was that workers who smoked demonstrated not only a significantly higher prevalence of cough, but also lower baseline and post-shift spirometric values compared to non-smokers. These facts indicate that smoking as well as exposure to endotoxin may play an important role in development of respiratory symptoms in the study population.

In the present study, 13.1% of workers suffered from work-related skin diseases. This prevalence rate was lower than that reported by Ewers and Tapp in American potato processing workers [6]. Skin symptoms occurred more frequently among workers of syrup producing division (23.1% vs. 5.7%; Fisher's test:  $p = 0.054$ ). This may be due to the much higher concentration of airborne dust detected in this division [3].

It has previously been reported that organic dust is capable of inducing skin diseases [10, 26, 27]. Śpiewak *et al.* [26, 27] described cases of airborne dermatitis in farmers exposed to hop and thyme dust. Hogan [10] revealed that 51.4% of the workers employed in grain elevators, where dust concentration is extremely high, complained of skin problems provoked by exposure to grain dust.

The common occurrence of work-related symptoms among potato processing workers was accompanied by a statistically significant across-shift decline in all measured spirometric values: FVC, FEV<sub>1</sub> ( $p < 0.001$ ), FEV<sub>1</sub>/VC ( $p < 0.05$ ), PEF ( $p < 0.01$ ). These decrements were not due to the normal circadian changes in lung function - this would have caused a slight increase in lung function.

Our findings are in agreement with the results of Dutch study. Zock *et al.* [30, 32] demonstrated that workers exposed to high endotoxin level experienced a greater over-shift decrease in average lung function values, than low exposure group.

In the present study, the lowest spirometric values (both baseline and post-shift) were observed in the group of smokers, and in subjects working over 4 years compared to non-smokers and workers employed for less than 4 years. This may suggest that smoking and longer occupational exposure may be interactive.

## CONCLUSION

Our data suggest that exposure to harmful agents in the potato processing industry may lead to development of skin, eye and respiratory symptoms among workers, accompanied by over-shift lung function decrease.

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