Pertanika J. Trop. Agric. Sci. 23(2): 61 - 66 (2000) ISSN: 1511-3701

Effects of Spice Dust on Lung Functions and Respiratory Symptoms in Spice Factory Workers in Selangor

HAMDAN NOOR, WAHIDAH SANSI, ZOLKEPLI OTHMAN and FARIDAH MOHAMAD
Jabatan Biologi, Fakulti Sains dan Pengajian Alam Sekitar,
Universiti Putra Malaysia
43400 UPM Serdang Selangor, Malaysia

Keywords: fine dust (PM10), lung function, vital capacity (VC), forced vital capacity (FVC)

ABSTRAK

Pendedahan kepada habuk rempah telah lama dikaitkan dengan penurunan fungsi paru-paru dan peningkatan simtom-simtom respirasi manusia. Kajian ini telah dijalankan untuk mengkaji kesan pendedahan tersebut ke atas fungsi paru-paru dan simtom respirasi di kalangan pekerja-pekerja tiga kilang rempah di Selangor. Pengukuran spirometri (VC, vital capacity; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second) telah dilakukan ke atas 56 pekerja (39 lelaki, 17 wanita), yang terdedah kepada habuk halus, PM_{10} sebanyak 2496µg/m^3. Subjek kajian juga mengisi satu set borang soal selidik kesihatan (soal selidik ATS yang diubahsuai) yang merangkumi simtom-simtom respirasi. 61 subjek dari UPM dipilih sebagai kawalan (36 lelaki, 25 wanita), dengan aras dedahan hanya 101µg/m^3. Kajian mendapati perbezaan yang signifikan bagi VC, FVC dan FEV_1 antara subjek kajian dan kawalan bagi kumpulan lelaki dan wanita. Di samping penurunan nilai-nilai spirometri, lebih ramai subjek daripada kumpulan pekerja melaporkan kejadian simtom-simtom respirasi berbanding kawalan. Oleh itu, kajian ini mencadangkan bahawa pendedahan kepada habuk rempah di kilang-kilang berkenaan membawa kepada pertambahan kejadian simtom-simtom respirasi dan penurunan fungsi paru-paru di kalangan pekerja-pekerjanya.

ABSTRACT

Exposure to spice dust has long been associated with increased prevalence of respiratory symptoms and reduced lung function in man. This study was carried out to investigate the effect of such exposure on the workersí lung function and respiratory symptoms in three spice-processing factories in Selangor. Spirometry measurements (VC,vital capacity; FVC, forced vital capacity; FEV_1, forced expiratory volume in 1 second) were performed on 56 workers (39 males, 17 females) who were occupationally exposed to 2496µg/m^3 respirable fine dust, PM_{10}. The subjects also completed a set of standard respiratory questionnaires (modified ATS questionnaires). 61 persons from Universiti Putra Malaysia (36 males, 25 females) served as controls. The PM_{10} measurement in UPM was only 101µg/m^3. Significant differences in VC, FVC and FEV_1 were observed between the two groups for both the male and the female. In addition to the decrease in spirometric values, the workers also reported higher prevalence of respiratory symptoms compared to controls. Therefore, the study suggests that exposure to spice dust in the spice factories leads to an increased prevalence of respiratory symptoms and impaired lung function.

INTRODUCTION

As a multi-racial country, Malaysians enjoy a variety of dishes; many are hot and spicy. One of the major food ingredients is spice; dried parts of various plants cultivated for their aromatic and pungent components. The spice includes chili pepper, cinnamon, coriander, ginger, garlic etc (Zuskin *et al.* 1988). Because of the high demand, spice-processing factories become one of the major food-processing industries in Malaysia, involving many labourers.

Since the process of spice preparation involves grinding, the labourers are constantly exposed to spice dust. The health of workers exposed to highly dusty environment (especially particles less than 10µm) is of serious concern because it has been implied that chronic pulmonary problems afflict one of every five persons exposed to dust. Such problems include reductions in spirometry values, increases in chest tightness, and also wheezing (U.S. National Research Council 1989).

Occupational exposure to spice dust has been reported to cause allergic reactions manifested by dermatological, gastrointestinal or neurological symptoms (Zuskin *et al.* 1988). Adverse effect of the exposure on the respiratory system has been widely reported elsewhere. Brooks (1985) reported an association between numerous spices and occupational asthma. The spices includes garlic dust (Felleroni *et al.* 1981), cinnamon (Uragoda 1984), coriander, mace, ginger and paprika (Toorenenbergen and Dieges 1985), and buckwheat aerosols (Gohte *et al.* 1983). Fuller *et al.* (1985) reported irritation of the airways in relation to inhaled capsicum aerosols. In terms of other respiratory symptoms, Uragoda (1966) observed a very high incidence of sneezing, runny nose and cough among workers occupationally exposed to chili peppers. Blanc *et al.* (1991) confirmed the association between the exposure with complaints of cough. A high percentage of upper respiratory tract infections (URTI) symptoms including sneezing and runny nose was also observed in spice grinders in Singapore (49.2%) as reported by Chan *et al.* (1990).

Despite the above-mentioned evidence, no study on this occupational hazard has yet been reported in Malaysia although there are a large number of spice-processing factories in this country. This study was carried out to investigate the effect of exposure to respirable spice dust (PM_{10}) to the lung function and respiratory symptoms of workers employed in three spice factories in Selangor.

MATERIALS AND METHODS

This study involved a total of 117 participants and the usage of health questionnaires (for respiratory symptoms survey), a spirometer (lung function test) and a diaphragm pump (dust measurement). All instruments were calibrated prior to every session of test in every study location.

Subjects and Locations

Three similar spice factories located in Selayang, Puchong and Rawang were randomly selected as the study locations to represent spice factories in Selangor and Universiti Putra Malaysia (UPM) for the control.

Since smoking and asthma are known to be among the dominant confounders in spirometry studies, only those who were non-smokers and non-asthmatics were randomly selected to perform the spirometry test. The selected 56 workers (39 males, 17 females) from the 3 factories were constantly exposed to mixed spice dust including coriander, turmeric, chili, pepper, cardamom and cloves during the work-shifts. Almost all subjects did not wear masks to protect against dust inhalation. Such exposure was not experienced by the 61 controls (36 males, 25 females).

All parameters known to be major confounders in spirometry studies (sex, age, height, race) were taken into account in the analysis (Table 1).

TABLE 1

Comparison of lung function measurements between study groups

	Male (mean ± SD)			Female (mean ± SD)		
	Controls(36)	Workers(39)	P value	Controls(25)	Workers(17)	P value
Age (years)	35.24 ± 62.46	37.05 ± 59.27	0.3934	29.96 ± 38.40	28.80 ± 33.43	0.5941
Height (cm)	163.49 ± 34.80	164.83 ± 34.53	0.2693	158.88 ± 25.65	156.25 ± 17.77	0.0479*
Weight (kg)	65.78 ± 72.36	67.78 ± 55.08	0.3431	54.00 ± 51.15	53.78 ± 20.16	0.9076
VC (L)	3.08 ± 3.24	2.65 ± 3.62	0.0005*	2.4 ± 1.45	1.75 ± 2.39	0.0000*
FVC (L)	3.14 ± 4.02	2.39 ± 3.56	0.0000*	2.46 ± 2.05	1.59 ± 2.89	0.0000*
FEV_1 (L)	2.26 ± 3.24	1.81 ± 3.18	0.0001*	1.89 ± 1.95	1.24 ± 2.72	0.0001*
FEV_1/FVC%	78.37 ± 3.05	71.36 ± 4.86	0.0311*	71.22 ± 3.42	68.74 ± 16.41	0.8472
$FEF_{25-75\%}$	1.93 ± 4.20	2.08 ± 7.37	0.4864	1.90 ± 2.90	1.38 ± 3.05	0.0065*
FMFT (s)	0.99 ± 3.36	0.86 ± 3.56	0.2564	0.84 ± 1.65	0.70 ± 0.91	0.0886

*significant difference (t-test, $p<0.05$)

Dust Measurement

Physiologically, only particles less than 10μm or PM_{10} (also termed as respirable dust) is known to be inhaled into the inner respiratory system, affecting the ventilatory lung function and also responsible for the prevalence of respiratory symptoms (Brewis 1985). Therefore, only PM_{10} was measured instead of total dust in the working areas. The PM10 concentration was determined using a diaphragm pump (Kimoto MP-1) that trapped particles less than 10μm on a 37mm diameter, 0.8μ pore size cellulose acetate filter paper. The PM_{10} concentration in $\mu g/m^3$ was calculated using the formula below:-

$$PM_{10}\ (\mu g/m3) = \frac{W(g) \times 10^9}{F(L/min) \times 10^{-3} \times T(min)}$$

W = weight of particles trapped on filter paper in gram

F = flow rate of air drawn into the sampling device (2L/min)

T = duration of sampling

The aerial sampling in both UPM and the factories was done continuously from 9.00 am-5.00 pm (working hours). The machine was placed as close to the workers as possible without disturbing them.

Lung Function Tests

Lung function tests were performed by the subjects during working hours using a spirometer (Vitalograph, England; ATS standards) with standard techniques (American Thoracic Society 1979). Each subject performed at least three attempts of VC (vital capacity) and FVC (forced vital capacity) with a gap of at least a minute between attempts. From the best curve, FEV_1 (forced expiratory volume in 1 second) was determined, and other parameters including $FEF_{25\text{-}75\%}$ (mid-expiratory flow volume) and FMFT (forced mid-expiratory flow time) were calculated. The measurements were then converted into BTPS unit. Height was also measured.

Respiratory Symptoms

Structured questionnaires based on the American Thoracic Society (1979) were distributed to each subject prior to lung function test. All of the participants were required to answer the questions in detail with regard to their personal and medical background, respiratory symptoms and history, smoking habit and occupational history.

RESULTS

Dust Measurement

Fig. 1 shows the values of PM_{10} concentration measured in UPM and the spice factories. In UPM, the dust concentration was only 101μg/m^3. The mean concentration in the factories was 2496μg/m^3, which was more than 20-fold higher than the control area. However, the level is far below the OSHA standards of 5000 for respirable dust for 8-hour exposure for workers. The high concentration measured in Factory 3 might be due to the non-stop working hours (2 shifts) and the fact that it was the largest operating spice factory compared to the other two. Despite the high concentration, the majority of the workers did not wear any mask.

Subjects

The subjects and controls were 16 to 59 years of age. Table 1 shows the physical background of the respondents. There is no significant difference in the physical parameters among the male

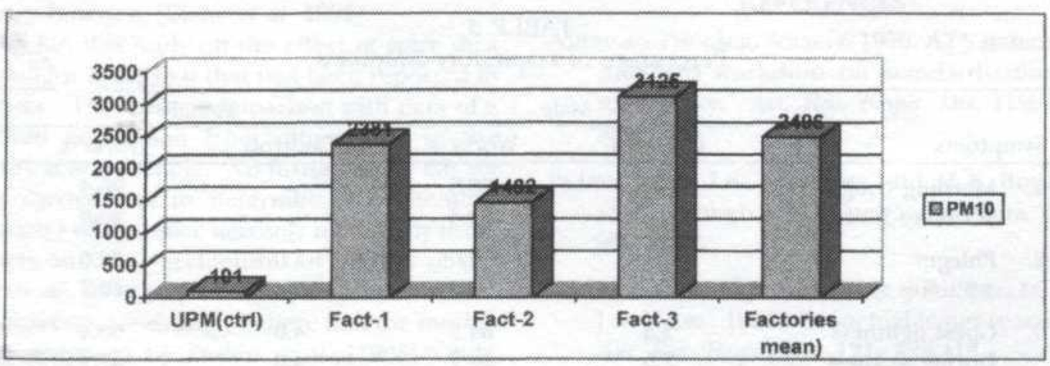

Fig. 1. Mean PM10 concentration in the control and study areas

subjects, while for the females, a significant difference was observed in height (t-test, $p<0.05$).

Lung Function Tests

Table 1 also shows the spirometry values of the subjects. The workers performed significantly lower VC, FVC and FEV_1 compared to controls (t-test, $p<0.05$) for both the male and female groups respectively. The male workers also exhibited lower FEV_1/FVC% compared to controls, suggesting a possible obstructive problem in their lungs. Since other confounders such as age and height between the male workers and controls did not show any significant difference, a reduction in their lung functions could possibly be associated with exposure to spice dust. In the female groups, the reductions in lung functions of the workers were expected due to the significantly lower values of height compared to controls. However, the reductions might also be attributed to the additive effect of exposure to high concentration of spice dust during working hours.

Table 2 shows the spirometry values of the male workers according to period of employment. The male workers (no difference in other physical characteristics) who had worked more than 5 years showed significantly lower mean values of VC and FVC compared to those with less duration of service. These statistical results suggest that lung function might worsen if the workers are constantly exposed to spice dust over a long period of time.

Respiratory Symptoms

Table 3 compares the prevalence of chronic respiratory symptoms in the workers and control subjects. The most frequently reported symptoms was morning coughs, experienced by more than 80% male workers compared to none for the controls; followed by chest tightness, experienced by most of the workers especially during work-shifts. The female workers showed a higher percentage of respiratory symptoms compared to controls and the male groups.

TABLE 2
Spirometry values of male spice workers according to period of employment in the spice factories

	Period of employment		
	Less than 5 years	More than 5 years	P-value
Number of subjects	15	24	
Age (years)	33.12 ± 11.58	37.48 ± 8.71	0.1359
Height (cm)	164.89 ± 5.69	162.04 ± 5.66	0.0798
Weight (kg)	64.85 ± 9.39	66.76 ± 14.45	0.5761
VC (L)	2.85 ± 0.44	2.44 ± 0.64	0.0105*
FVC (L)	2.58 ± 0.32	2.22 ± 0.72	0.0250*
FEV1 (L)	1.85 ± 0.35	1.77 ± 0.40	0.5694
FEF25-75%	1.95 ± 0.70	2.21 ± 1.54	0.4359
FMFT (s)	0.94 ± 0.59	0.78 ± 0.54	0.3191

*significant difference (t-test, $p<0.05$)

TABLE 3
Percentage of respiratory symptoms

	Male		Female	
Symptoms	Controls	Workers	Controls	Workers
1. Morning cough	–	86.3	–	96.4
4-5 times a week	–	29.4	–	25.0
2. Phlegm	2.5	49.0	4.0	50.0
4-5 times a week	–	9.8	–	10.7
3. Chest tightness	2.5	84.3	4.0	96.4
During sickness	2.5	62.7	4.0	57.1
During workshift	–	76.5	–	75

DISCUSSION

Our study suggests that constant exposure to high levels of spice dust in spice factories (even below the OSHA standards) might have possible adverse effects on the lung functions of the workers. Studies done on Yugoslavian spice workers showed similar findings even though the workers were exposed to a much lower dust concentration (Zuskin *et al.* 1988).

Despite the homogeneity in age, height and weight (determinants of lung capacity) between the participants, the workers showed significantly lower values of VC, FVC and FEV_1 compared to controls. Therefore, the reduction might be attributed to the difference in exposure level between the study groups.

The effect of spice dust on the workers was further evidenced by the significantly lower spirometry values shown by workers who have worked for more than 5 years, despite the insignificant difference in other confounders compared to those with less period of service. This observation strengthens our hypothesis that reduction in lung function is strongly associated with the constant exposure to spice dust over a long period of time.

Besides this chronic decrease in lung function, Zuskin *et al.* (1988) also reported acute reductions in lung functions after a work-shift in spice factory workers. Other researchers had also observed similar trend in workers exposed to tea and coffee dust (Jayawardana and Udupihille 1997; Zuskin *et al.* 1979; Zuskin and Skuric 1984).

As expected, higher prevalence of respiratory symptoms was reported by the workers. This phenomenon is in perfect agreement with other studies elsewhere, some of which had reported a higher incidence of respiratory symptoms even without significant reduction in pulmonary function (Blanc *et al.* 1991).

So far, this study on the effect of spice dust in Selangor is the first that had been reported in Malaysia. Therefore, comparison with data of a matched population from other parts of the country is not possible. No further study has yet been carried out to determine the chemical properties of the spice aerosols inhaled by these workers and the mechanisms of toxicity of the aerosol on their respiratory system.

However, we strongly believe that the mechanisms proposed by Zuskin *et al.* (1988) could play an important role in reducing lung function and increasing the prevalence of respiratory symptoms in the spice workers. The mechanisms include hyperreactivity due to increased permeability of the airway mucosa to irritants, resulting in the direct effect on the airway muscle damage to the airway mucosa, as represented by the presence of cough in most of the workers (Nadel *et al.* 1954; Boushey *et al.* 1980;) repeated damage of the airway epithelium (Widdicombe 1954); and development of inflammation in the airways causing airway responsiveness (Cooper *et al.* 1986).

Zuskin *et al.* (1988) also suggested that the adverse effects of spice dust might be due to the release of mediators in the airway that might constrict airway smooth muscle directly or by reflex. Using disodium cromoglycate (DSC), they reported that spice dust affects airway cells causing the release of these mediators and therefore concluded that food spice has a bronchoconstrictor potential, resulting in reduced lung function and increased prevalence in respiratory symptoms, as observed in this study.

CONCLUSION

Observation from this study suggests that exposure to high PM_{10} of spice dust in spice-producing factories in Selangor leads to increased prevalence of respiratory symptoms in the workers. The decrease in lung function among the workers also suggests that they might be facing other acute and chronic lung diseases. In addition, the high concentration of dust measured in the factories suggests that there is a need to improve the ventilation in these factories, and introduce personal protective equipment such as mask, in order to safeguard the respiratory system of workers.

REFERENCES

AMERICAN THORACIC SOCIETY. 1979. ATS statement-snowbird workshop on standardization of spirometry. *Am. Rev. Respir. Dis.* **119:** 831-838.

BLANC, P., D. LIU, C. JUAREZ and H.A. BOUSHEY. 1991. Cough in hot pepper workers. *Chest* **99:** 27-32.

BOUSHEY H.A., M.J. HOLTZMAN, J.R. SHELLER and J.A. NADEL. 1980. Bronchial hyper-reactivity. *Am. Rev. Respir. Dis.* **121:** 389-413.