Pulmonary Function, Hematological Parameters and Inflammatory Markers in Workers Exposed to Wheat Flour Dust in Najaf City

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Abstract

Wheat flour mill dust might cause adverse health effects in exposed workers. The objective of this study was to evaluate the pulmonary functions, hematological parameters and inflammatory markers of workers from different flour mills. The measurement of pulmonary function parameters was performed by using an electronic spirometer on 80 non-smoker male workers from flour mills with mean age of 34.01±8.17 years, mean duration of employment 8.7±4.23 years and 70 unexposed non-smoker individuals constituted control group. Additionally, the study also determined complete blood count, serum IL-6 and IL-8 for 48 non-smoker male workers from flour mills and 37 unexposed non-smoker individuals' subjects as control group. Study populations were divided into three groups depending on the nature of job that involved sweepers [high exposure group], packers [intermediate exposure group] and millers [low exposure group]). The results showed a significant decrease ($P \leq 0.05$) in values of FVC, FEV1, FEV1/FVC%, FEF 75% and MVV in sweepers, packers and packers as compared to control. Furthermore, the results indicated a significant prevalence at $P \leq 0.001$ of respiratory symptoms such as shortness of breath, cough, phlegm, wheezing, chest pain and chest tightness among in all three job titles as compared to the control group. Also, the hematological parameters revealed significant increased at $P \leq 0.05$ in RBCs, Hb and PCV in sweepers and packers compared to the control group. However, the results also showed a significant decrement at $P \leq 0.05$ in mean corpuscle hemoglobin concentration (MCHC) and mean corpuscle hemoglobin (MCH) in sweepers and packers compared with the control group. In addition, the study demonstrated a significant increment at $P \leq 0.05$ in total leukocytes count for different categories compared with the control group. Also, percentage of eosinophils and absolute eosinophils cell count was significantly increased at $P \leq 0.05$ in sweepers and packers. Moreover, serum IL-6 was significant increment in different job categories compared with their control. The results also demonstrated that there was a significantly elevated at $P \leq 0.05$ of serum IL-8 in workers compared with control group.

Keywords: Mill workers, wheat flour dust, occupational exposure, pulmonary function test, Hematology, inflammation

{**Citation:** Sami R. Al-Katib, Zaid M. AL-Hakkak. Pulmonary function, hematological parameters and inflammatory markers in workers exposed to wheat flour dust in Najaf City. American Journal of Research Communication, 2016, 4(10): 1-9} www.usa-journals.com, ISSN: 2325-4076.

Introduction

Flour mills are well known for generation and release of dust particles into the air, and are then inhaled during industrial processes, such as bagging, grinding, cleaning, and even transporting (Bachanek *et al.*, 1999). Wheat flour dust is a complex organic dust with allergic elements (Zuskin *et al.*, 1998). In addition, it may contain a large number of contaminants including silica, fungi and their metabolites (aflatoxin), bacterial endotoxin, insects, mites, mammalian debris and various chemical additives such as pesticides and herbicides (Dhillon and Kaur, 2011). Previous studies showed that occupational exposure to the wheat flour dust caused sensitization, allergic rhinitis, occupational asthma, conjunctivitis and impairment in lung functions parameters such as forced vital capacity (FVC), forced expiratory volume in the first second (FEV1), peak expiratory flow (PEF) and maximum voluntary ventilation among bakers and wheat flour mill workers (Arrandale *et al.*, 2013; Tawde *et al*., 2015; Rafiee-Pour *et al.*, 2015). Inhalation of wheat flour dust could induce allergic disorders, chronic respiratory diseases and occupational asthma (Latha *et al.*, 2015). Chattopadhyay *et al.* (2007) investigated differential count of leucocytes in 156 storage grain workers in India. The results led to increment of blood eosinophil level in the total storage grain workers. Moreover, chronic inhalation of grain dust caused airway obstruction, neutrophils recruitment to the lung and an increase in the concentration of neutrophils in the bloodstream (Clapp *et al*. 1994). Another study was carried out by Wohlford-Lenane *et al.* (1999) found that inhalation of grain dust led to release proinfammatory cytokine (TNF- α and IL-6) and chemokines (IL-8 and macrophage inflammatory protein-2) for up to 48 hours. These mediators are actively produced by macrophages and neutrophils. Most studies on the effect of flour dust exposure in humans have tended to focus on the respiratory system. However, few studies were investigated on blood parameters and inflammatory cytokines in flour mill workers. Large number of workers were engaged in flour mills in Najaf city so it is necessary to evaluate health hazards in this group workers. This study therefore aims to evaluate the pulmonary functions, hematological parameters and inflammatory markers of workers in Najaf city in Iraq.

Materials and Methods

This study was conducted in three major flour milling industries in Najaf city in Iraq, in the period January-June 2015. It included flour mill workers were exposed to wheat flour dust during their work hours in flour mills. Those flour mill workers worked for at least 8–10 hours a day for 6 days per week. Pulmonary function tests were carried out in 80 non-smoker male flour mill workers in the mean age of 34.01±8.17 years and mean duration of employment 8.7±4.23 years and 70 non-smoker male control subjects. Spirometric tests were performed for all participants by using a portable Spirolab III a computerized diagnostic spirometer, made by (MIR Medical Research International, Rome, Italy). Data was collected through direct interview in the workplace using prepared questionnaire in the three major flour milling industries. It contained items related to personal and family history of allergy, respiratory symptoms and duration of employment. Additionally, the study also determined complete blood count, IL-6 and IL-8 on 48 non-smoker male flour mill workers and 37 subjects as control group. Study populations were divided into three groups depending on the job categories (sweepers [high exposure group], packers [intermediate exposure group] and millers [low exposure group]).

Five ml of venous blood were collected from each participant by venipuncture. 2ml of the blood samples were collected into plastic tube containing EDTA for hematological studies. The remaining 3ml of blood samples was deposited in anticoagulant free plastic tube and allowed to clot at room temperature within 3 hours of collection, followed by separation of serum from the clot. The serum samples were stored at deep freeze (-20˚ C) to be used for enzyme immunoassay for inflammatory

markers studies. Hematological parameters of blood samples were determined with automated hematology analyzer Sysmex K-1000 (TOA Med Elect., Co., Ltd., Kobe, Japan). The system is a fully automated qualitative hematology analyzer for in vitro diagnostic use in clinical laboratories. It provided a quick screening for hematological testing. Moreover, Sera IL-6 and IL-8 were measured using an ELISA kit (US Biological U.S.A) according to the manufacturer's instructions. All blood samples were analyzed in Najaf hospital.

Statistical analysis was performed in this study using the computer Software Statistical Package of Social Science (SPSS 14, SPSS Inc., Chicago, USA) and Microsoft® Excel® 2010 part of Microsoft Office Professional Plus 2010, Microsoft Corporation. The independent sample t-test was used for comparing means of quantitative variables across two groups. One way analysis of variance (ANOVA) was used to perform between and within comparison of quantitative data across more than two groups. Results were reported as (mean±SD). P≤ 0.001 and P≤ 0.05 were considered a statistically significant (Daniel, 2010).

Results

The physical parameters such as age, weight, height and Body mass index (BMI) of both the control and wheat flour mill workers showed no significant difference. The results of the study showed that the mean percent predicted values of FVC, FEV1, FEV1/FVC%, FEF 75% and MVV of the three work categories which involved sweepers, packers and packers were significantly decrease at P≤ 0.05 compared with the control group. The greater difference was noticed between the control group and sweepers. In addition, the mean of % predicted values FEF 25-50% and FEF 25% of sweepers and packers were both significantly dropped at P≤ 0.05 compared with the control group. Moreover, the mean of % predicted value FEF 50% of packers and millers was both significantly reduced at P ≤ 0.05 compared with the control group (Table 1).

Table (1): Physical characteristics and the percent predicted of pulmonary function tests among wheat flour mill workers according to the job categories and control group

Parameters	Control (n=70) (Mean±SD)	Wheat flour-exposed workers (n= 80)		
		Sweepers (n=25) (Mean±SD)	Packers(n=25) (Mean±SD)	Millers(n=30) (Mean±SD)
Age (years)	34.8±8.13	34.33±6.8	34.52±8.17	33.12±9.79
Height (m)	1.69±0.006	1.70±0.005	1.70±0.005	1.67±0.013
Weight (kg)	64.21±1.166	64.36±2.149	64.44±2.286	64.76±1.72
BMI (Kg/m^2)	22.36±0.399	22.03±0.69	22.05±0.73	23.07±0.61
FVC (%Pred.)	94.52±1.69	$72.4±3.70^{a}$	$74.72±0.96^{a}$	$74.96±2.28^{a}$
FEV1 (%Pred.)	112.15±1.98	$83.36±4.691^{a}$	$85.44±0.88^{a}$	$86.46±2.84^{a}$
FEV1/FVC% (%Pred)	123.71±0.61	$119.24±1.84^{a}$	$111.92±3.54^{a,b}$	$119.36±0.72^{a,c}$
FEF 25-50% (%Pred)	162.24±4.84	$125.2±6.33^{a}$	$132.96±7.3^{a}$	$152.03±6.5^{b}$
FEF 25% (%Pred.)	114.52±2.4	$90.24±4.7^{a}$	$90.52±4.09^{a}$	$112±3.25^{b.c}$
FEF 50% (%Pred.)	141.25±3.769	113±5.731	$123.96±4.9^{a}$	$137.03±5.4^{a,b}$
FEF 75% (%Pred.)	229.52±9.11	$149.72±9.4^{a}$	$188.2±11.2^{a,b}$	$193.93±9^{a,b}$
MVV (%Pred.)	109.98±2.174	$82.52±4.6^{a}$	$83.20±1.1^{a}$	$83.63±1.7^{a}$

Notes: % Pred. = percent of predicted values. (a) = indicate significant difference as compared with control at P≤ 0.05. (b) = indicate significant difference as compared with sweepers at P≤ 0.05. (c) = indicate significant difference as compared with packers at P≤ 0.05.

Regarding distribution of respiratory symptoms. The results indicated that highly significantly elevated at P≤ 0.001 in prevalence of percentage of shortness of breath, cough, phlegm, wheezing, chest pain and chest tightness among in all three job titles (sweepers, packers and millers) compared with the control group. Moreover, the statistical analysis showed significant increment at P≤ 0.05 in percentages of respiratory symptoms like cough (80%), shortness of breath (68%) and chest pain (68%) for sweepers comparison to the millers (Table 2).

Table (2): Prevalence of respiratory symptoms among wheat flour mill workers according to the job categories and control group

Respiratory symptoms	Control (n=70) No. (%)	Wheat flour-exposed workers (n= 80)		
		Sweepers (n=25) No. (%)	Packers(n=25) No. (%)	Millers(n=30) No. (%)
Shortness of breath	6(8.5%)	17(68%)[a]	13(52%)[a]	10(33.3%)[a,b]
Cough	8(11.4%)	20(80%)[a]	17(68%)[a]	12(40%)[a,b]
Phlegm	6(8.5%)	15(60%)[a]	13(52%)[a]	11(36.7%)[a]
Wheezing	2(2.8%)	14(56%)[a]	11(44%)[a]	4(13.3%)[a,b,c]
Chest pain	4(5.7%)	17(68%)[a]	12(48%)[a]	8(26.6%)[a,b]
Chest tightness	4(5.7%)	13(52%)[a]	11(44%)[a]	5(16.6%)[a,b,c]

Notes: (a) = indicate significant difference as compared with control at P≤ 0.05. (b) = indicate significant difference as compared with sweepers at P≤ 0.05. (c) = indicate significant difference as compared with packers at P≤ 0.05.

The study revealed that there was significantly increased at P≤0.05 in the total red blood corpuscles (TRBCs), hemoglobin (Hb) and packed cell volume (PCV) of packers and millers compared with the control group. The results also recorded significant at P≤0.05 decrement in mean corpuscle hemoglobin concentration (MCHC) and mean corpuscle hemoglobin (MCH) in sweepers and packers compared with the control group (Table 3).

Table (3): Total and red blood corpuscles indices among flour mill workers according to the job categories and control group

Parameters	Control (n=37) (Mean±SD)	Wheat flour-exposed workers (n= 48)		
		Sweepers(n=16) (Mean±SD)	Packers(n=16) (Mean±SD)	Millers(n=16) (Mean±SD)
Total RBCs ($\times 10^6$) (corpuscle/mm^3)	4.914±0.0287	5.33±0.042	5.39±0.055[a]	5.72±0.066[a]
Hb (g/dl)	13.375±0.049	14.21±0.162[a]	14.48±0.06[a,b]	13.94±0.28[a,c]
PCV (%)	39.767±0.259	45.00±0.23[a]	45.11±0.23[a]	44.4±0.74[a,b,c]
MCV (fL)	80.44±0.044	80.33±0.67	80.22±0.69	77.7±0.38[a,b,c]
MCH (pg)	27.013±0.108	26.98±0.35[a]	26.40±0.15[a]	24.31±0.22
MCHC (g/dl)	33.518±0.139	31.96±0.25[a]	32.03±0.09[a]	31.91±0.06[a]

Notes: (a) = indicate significant difference as compared with control at ≤ 0.05. (b) = indicate significant difference as compared with sweepers at P≤0.05. (c) = indicate significant difference as compared with packers at P≤ 0.05.

In addition, the results showed that that there was significantly elevated at P≤0.05 in total leukocytes count for different categories (sweepers, packers and packers) when compared with the control group. In differential count of leukocytes, the statistical analysis showed that there was significant at P≤0.05 increment in percentage of neutrophils of sweepers compared with the control group and other job categories. Furthermore, the results also recorded significantly higher at P≤0.05 proportion of lymphocytes for packers in comparison with control group and other different categories (Table 4). Furthermore, the statistical analysis also illustrated that the percentage of eosinophils and absolute eosinophil cells count was significantly at P≤0.05 elevated percentage of eosinophils and absolute eosinophils cell in sweepers and packers compared with control group and millers (Table 4).

Table (4): Physical characteristics and total and differential counts of leukocytes among flour mill workers according to the job categories and control group

Parameters	Control (n=37) (Mean±SD)	Wheat flour-exposed workers (n= 48)		
		Sweepers (n=16) (Mean±SD)	Packers (n=16) (Mean±SD)	Millers (n=16) (Mean±SD)
Age (years)	35.83±8.3	35.5±9.59	35.87±9.27	36.12±6.13
Height (m)	1.706±0.0286	1.71±0.028	1.706±0.025	1.703±0.033
Weight (kg)	64.89±11.76	64.93±10.96	65.75±11.33	64±13.5
BMI (Kg/m^2)	22.19±3.73	22.1±3.63	22.52±3.6	21.95±4.16
Total leukocytes count ($cell/mm^3$)	6041.8±83.9	8503.12±83.9[a]	7893.7±377.4[a]	7996.8±342.4[a]
Neutrophils (%)	53.58±0.347	57.13±1.93[a]	49.58±1.79[a,b]	56.42±1.31[c]
Lymphocytes (%)	35.986±0.395	31.27±1.37[a]	38.71±1.45[a,b]	33.83±1.16[c]
Monocytes (%)	7.19±0.244	7.0±0.412	7.43±0.388	6.51±0.255
Eosinophils (%)	2.2932±0.113	3.66±0.603[a]	3.36±0.39[a]	2.26±0.353[b,c]
Basophils (%)	0.94±0.055	0.96±0.109[a]	0.89±0.086[a]	0.96±0.044
Absolute eosinophil count ($cell/mm^3$)	139.19±7.006	313.59±57.83[a]	277.86±44.62[a]	179.64±27.1[b,c]

Notes: (a) = indicate significant difference as compared with control at P≤ 0.05. (b) = indicate significant difference as compared with sweepers at P≤0.05. (c) = indicate significant difference as compared with packers at P≤ 0.05.

The study found the concentration of serum IL-6 was a significant increment in different job categories of wheat flour mill workers compared with their control. This study demonstrated that there was a significantly elevated at P≤0.05 of serum IL-8 in millers compared with control group and other job categories (Table 5).

Table (5): Serum levels of IL-6 and IL-8 among wheat flour mill workers according to the job categories and control group

Parameters	Control (n=37) (Mean±SD)	Wheat flour-exposed workers (n= 48)		
		Sweepers (n=16) (Mean±SD)	Packers (n=16) (Mean±SD)	Millers (n=16) (Mean±SD)
IL-6 (pg/ml)	9.1564±0.004	9.415±0.019[a]	9.626±0.004[a,b]	9.366±0.03[a,c]
IL-8 (pg/ml)	28.298±1.1	33.62±5.709	28.864±1.98	75.35±9.68[a,b,c]

Notes: (a) = indicate significant difference as compared with control at (P≤ 0.05). (b) = indicate significant difference as compared with sweepers at P≤ 0.05. (c) = indicate significant difference as compared with packers at P≤0.05.

Discussion

The finding of the present study reported that there was a significant decrement (P≤0.05) in % predicted values FVC , FEV1 , FEV1/FVC%, FEF 75% and MVV of the three different job titles of all workers as compared with their matched control group .These results agreed with (Somani *et al.*,2014). This finding probably due to contact workers in different workstations of mills with high level of flour dust in the workplace because of all workstations at the flour mill were generally filled with visible dust. Nayak et al (2013) stated workers inhaled high levels of flour particles during industrial processes, such as cleaning, wheat grinding, packaging and transporting caused lung irritation, mucus hyper secretion initially, followed by lung function impairment, lung inflammation chronic obstructive lung disease and restrictive lung disease.

Concerning prevalence of respiratory symptoms, the results demonstrated that significant increment at P≤ 0.05 in percentages of respiratory symptoms (shortness of breath, cough, phlegm, wheezing, chest pain and chest tightness) among three different job titles of all workers compared to the control group. Similar findings were recorded by other studies (Neghab *et al*., 2012; Tosho *et al.*, 2015). Hosseinabadi *et al. (*2013) reported high prevalence of respiratory symptoms such as sputum in the morning, tightness of breath, short of breath and work cough during work in flour mill workers. The prevalence of respiratory symptoms in flour mill workers might be due to exposed workers at three different jobs categories to large levels of flour dust led to occupational airway disease and prevalence respiratory symptoms.

The results of hematological parameters revealed that there was significantly increased at P≤0.05 in the total red blood corpuscles (TRBCs), hemoglobin (Hb) and packed cell volume (PCV) of packers and millers compared with the control group. This result perhaps due to high exposure of wheat flour dust caused airway obstruction that led to alveolar hypoxia .Hypoxia increases renal erythropoietin secretion, which, in turn, stimulates bone marrow production of more number of RBC and Hb in the circulating blood. Kent *et al.* (2011) mentioned lung disease cause secondary polycythemia.

Furthermore, the results indicated a significant at P≤0.05 decrement in mean corpuscle hemoglobin concentration (MCHC) and mean corpuscle hemoglobin (MCH) in sweepers and packers compared with the control group. This pattern might be caused by increased consumption of iron that need to formation RBCs, which let to hypochromic. Wildman *et al.* (1976) suggested that low hemoglobin production because of exposure to flour dust induced disturbance of heme-biosynthesis. Moreover, drop in mean corpuscular hemoglobin concentration (MCHC) reported by Isselbacher *et al*. (1992)

might be due to reduce of biosynthesis of heme in bone marrow. Similar findings were recorded by Tripathi *et al.* (2014) who showed that decrease in MCHC in male workers exposed to rice husk dust.

The present study revealed that that there was significantly elevated at P≤0.05 in total leukocytes count for different categories (sweepers, packers and packers) when compared with the control group. This results agreed with the outcomes of Kolopp-Sarda *et al.* (1995) found exposure to wheat flour dust caused airway inflammation. This raised in total leukocytes count probably due to reaction to irritant flour dust lodged in the lung leading to airway inflammation of wheat flour mill workers.

Regarding differential leukocytes count, the statistical analysis showed that there was a significant at P≤0.05 increment in percentage of neutrophils of sweepers compared with the control group and other job categories. Similar findings were recorded by Von Essen et al. (1990) found neutrophils elevated in the airways of farmers at grain harvest time. Grain dust had been shown to activate alveolar macrophages and cause a neutrophilic infiltration of the lower respiratory tract (Keller *et al.*, 1987). Similar results were recorded by Ijadunola *et al.* (2005) found inhalation of grain dust was associated with the development of airflow obstruction, neutrophils recruitment to the lung, and an increase in the concentration of neutrophils in the blood.

The result also illustrated that the percentage of eosinophils and absolute eosinophils were significantly at P≤0.05 elevated in sweepers and packers compared with control group and millers. The significant increase in eosinophil in flour mill workers might be attributed to increase of activation of allergic response. The eosinophils played an important role in the defense mechanism of the body and their count increased during allergic conditions and parasitic reaction (Semibulingam and Perma, 2006). Mohammadien *et al. (*2013) reported that prevalence of allergic symptoms in flour mill workers was related to irritation and sensitization to flour particles at workplace rather than to chronic permanent damage.

Furthermore, the results recorded that there was a significant highest at P≤0.05 proportion of lymphocytes for packers in comparison with control group and other different categories. Lymphocytosis in packers might be due to the body's defense mechanism to produce more antibodies to combat the inhaled materials which ultimately found their way into the systemic circulation. Packing workers direct contact with the flour dust in ambient environment during loading flour sacks, the respiratory tract was often the site of injury from occupational exposures. This finding agreed with study of Saetta *et al.* (1998) that reported chronic airflow limitation had an increase in number of $CD8^{+}$T-lymphocytes and an increase smooth muscle area in the peripheral airways.

This study found the concentration of serum IL-6 was significant increment in different job categories compared with their control, this finding agreed with results of previous study by Marraccini *et al.* (2016) found serum IL-6 concentrations were significantly higher in flour workers at P<0.01 than in individuals in the healthy group. They concluded that cytokines produced a defensive response in occupational asthma and atopic. This indicates might be caused by exposure endotoxins principal component of grain dust responsible for bronchial airway inflammation led to induction of the pro-inflammatory cytokines from airway epithelium. Similar findings were recorded by Blaski, *et al.* (1996) who found inhalation of grain dust after 8 hours was associated with marked decrements in airflow as well as with markedly increase in proinflammatory cytokines in study group. The results of present study indicated that flour dust might cause an inflammatory response in lung epithelial cells.

In addition, this study demonstrated that there was significantly elevated at P≤0.05 of IL-8 serum in millers compared with control group and other job categories. This finding was similar to results of other study in Korea by Hae-Sim *et al.* (2000) who stated that IL-8 produced from bronchial

epithelial cells might be a major cytokine, which induced neutrophil migration into the airways when exposed to grain dust. This result might be attributed to lung inflammation caused by millers repeated exposure to high concentration to flour dust during milling wheat in workplace. Held and Uhlig (2000) showed airborne exposure to components of grain dust and endotoxin related to both acute and chronic respiratory impairment in workers of grain storage and transfer industries .This result probably due to contain wheat dust of high level of endotoxin that stimulated IL-8 production by endothelial cells, fibroblasts, macrophages, and monocytes and actively recruit neutrophils to the site of chronic lung inflammation.

References

Arrandale V, Meijster T., Pronk A. Doekes G and Redlich C. (2013). Skin symptoms in akery and auto body shop workers: associations with exposure and respiratory symptoms. Int Arch Occup Environ Health, 86:167–175.

Bachanek T., Chalas R., Pawlowicz A. and Tarezydto B. (1999). Exposure to flour dust and the level of abrasion of hard tooth tissues among the workers of flour mills. Ann Agric Environ Med, 6 (2):147–9.

Blaski C.A., Clapp W.D., Thorne P.S., Quinn T.J., Watt J.L., Frees K.L., Yagla S.J. and Schwatz D.A. (1996). The role of atopy in grain dust-induced airway disease. Am J Respir Crit Care Med 154:334– 340.

Chattopadhyay B.P., Mahata A and Kundu A. (2007). A study on blood eosinophil level and ventilator pulmonary function of the workers exposed to storage grain dust .Indian Journal of Occupational and Environmental Medicine, 11, 1: 21–25.

Clapp W.D., Becker S., Quay J, Watt J.L, Thorne P.S., Frees K.L., Zhang X and Schwartz, D.A. (1994). Grain dust-induced airflow obstruction and inflammation of the lower respiratory tract. Am. Rev. Respir. Crit. Care Med. 150:611-617.

Daniel W.W. (2010). Biostatistics: Basic Concepts and Methodology for the Health Sciences. John Wiley & Sons, Incorporated.

Dhillon S.K. and Kaur, H. (2011).Study of effect of flour dust and rice husk dust on Pulmonary Functions, Indian J. Fund Appl. Life Sci. 1 (4), 100–106.

Hae-Sim P., Jung-Hee S., Sun-Sin K and O-ung K. (2000). Grain dust induces IL-8 production from bronchial epithelial cells: effect on neutrophil recruitment. Ann Allergy Asthma Immunol., 84:623– 627

Held H.D. and Uhlig S. (2000). Mechanisms of endotoxin-induced airway and pulmonary vascular hyperreactivity in mice. Am J Respir Crit Care Med, 162:1547–1552.

Hosseinabadi M.B. Krozhdeh J, Khanjani N., Zamani A. and Ranjbar M. (2013). Relationship between Lung Function and Flour Dust in Flour Factory Workers. Journal of Community Health Research. 2(2):138-146.

Ijadunola K.T., Onayade A.A, Ijadunola M.Y., Fatusi, A.O. and Asuzu M.C. (2005). Pulmonary Functions of Wheat Flour Mill Workers in flour processing workers in the baking industry. Am J Ind Med 27(3): 359–365.

Isselbacher K. I., Braunwald E. and Wilson, J. D. (1992). Harrison's principle of internal medicine. New York McGraw-Hill38 – 47.

Keller G.E.I., Lewis, D. M. and Olenchock. S. A. (1987). Demonstration of inflammatory cell population changes in rat lungs in response to intratracheal instillation of spring wheat dust using

lung enzymatic digestion and centrifugal elutriation. Compo Immuno. Microbiol. Infeet. Dis. 10:219-226.

Kent B.D., Mitchell P.D. and McNicholas W.T. (2011). Hypoxemia in patients with COPD: cause, effects, and disease progression. International Journal of COPD, 6: 199–208

Kolopp-Sarda, M.N.; Bene, M.C. and Massin, N. (1995). Altered partition of T-cell subsets in the peripheral blood of healthy workers exposed to flour dust. Am J Ind Med, 28: 497-504.

Latha G.M., Sarala K. and Gouroju Sh. (2015). Effect of Construction and Flour Mill Air Pollution in Rural Area. Int J Intg Med Sci,2(2):49-54.

Marraccini P., Cantone, L., Barretta F., Marsili, Ch., Leghissa P., Santini, M., Elli, F., Bertazzi P. and Previdi M.(2016). Inflammatory markers and genetic polymorphisms in workers exposed to flour dust. J.of occup.and environmental med. 58, 5- p e166–e170.

Mohammadien H. A., Hussein M.T. and El-Sokkary, R.T. (2013). Effect of exposure of flour dust on respiratory symptoms and pulmonary functions. Egyptian journal of chest diseases and tuberculosis, 62, 4: 745-753.

Nayak Y., Kacha Y., Mehta H., Shah C., Vegad A. and Varu, M. (2013). Effects of flour dust on computerized spirometric parameters in flour mill workers. International Journal of Basic and Applied Physiology, IJBAP, 2(1): 208-212.

Neghab M., Soltanzadeh A., Alipour A., Hasanzadeh J. and Alipour H. (2012). Respiratory morbidity induced by occupational inhalation exposure to high concentrations of wheat flour dust. International Journal of Occupational Safety and Ergonomics, 18, 4: 563-569.

Rafiee-Pour A; Rafiee-Pour E., Asghari M Zadeh N.G. and Dehghan S.F. (2015). Respiratory effects of exposure to flour dust: A case study among workers of flour production factories in Arak. JPS, 6, 3 :79-84.

Saetta M., Di Stefano A. and Turato G. (1998). $CD8^+$ T-Lymphocytes in Peripheral Airways of Smokers with Chronic Obstructive Pulmonary Disease. American Journal of Respiratory and Critical care medicine, 157: 822-826.

Somani S., Handergulle S. and Prema J. (2014). Effect of flour dust on pulmonary functions in flour mill workers in marathawada region. IJBAP, Vol 3(1).

Tawde P.M., Kazi A.H, Gunjal S.B, and Jaiswal A.V. (2015). Effects of Breathing Exercise and Preventive Measure on Pulmonary Functions in Flour Mill Workers. International Journal of Health Sciences & Research, 5, 7: 241.

Tosho A.S., Adeshina A.I., Salawu M. and Tope, A.J. (2015). Prevalence of Respiratory Symptoms and Lung Function of Flour Mill Workers in Ilorin, North Central Nigeria. International Journal of Research & Review 56, 2: 3.

Tripathi A., Singh N.B., Bansode F.W. and Singh R.K. (2014). Hematological Complications in Rice mill workers of district Allahabad, Uttar Pradesh. Bull. Env. Pharmacol. Life Sci., 4[1]: 101-102.

Von Essen S.G., Thompson A.B., Robbins R.A., Jones, K.K., Dobry C.A. and Rennard S.I. (1990). Lower respiratory tract inflammation in grain fanners. Am J Ind Med 17:75-76.

Wildman J. M., Freedman M. L, Rosman, J. and Goldstein B. (1976). Benzene and lead inhibition of rabbit reticulocyte heme and protein synthesis: evidence for additive toxicity of these two components of commercial gasoline. Res. Commun. Chem. Pathol. Pharmacol., 13(3):473-88.

Wohlford-Lenane C.L., Deetz D.C. and Schwartz, D.A. (1999). Cytokine gene expression after inhalation of corn dust. Am J Physiol Lung Cell Mol Physiol 276: L736–L743.

Zuskin E., Kanceljak B., Schachter E.N., Godnic-Cvar J., Mustabegovic J. and Budak A. (1998). Respiratory function and immunological status in cocoa and flour processing workers. American Journal of Industrial Medicine 33(1): 24-32.