Iranica Journal of Energy & Environment 4 (2): 150-154, 2013
ISSN 2079-2115
IJEE an Official Peer Reviewed Journal of Babol Noshirvani University of Technology
DOI: 10.5829/idosi.ijee.2013.04.02.12

BUT

Indoor Air Quality Assessment with Emphasis on Flour Dust: A Cross-Sectional Study of a Random Sample from Iranian Bakeries Workers

Seyedtaghi Mirmohammadi

Department of Occupational Health, Faculty of Health,
Mazandaran University of Medical Sciences, Sari, Iran

(Received: November 18, 2012; Accepted in Revised Form: February 12, 2013)

Abstract: This cross-sectional study investigates the time weighted average (TWA) exposure of bakeries workers to the particulate matters concentration in the randomly selected bakeries workers. Air samples were collected from worker inhalation area in the workplaces by personal sampling method (PTFE Membrane SKC Filter with 25 mm, 2.0-µm pore sizes and SKC personal samplers pump with flow rate of 2 L/min). Filters were weighted by digital balance before and after sampling in the controlled laboratory. It was found that particulate matters concentration was higher than the National Institute of Occupational Safety and Health (NIOSH) permissible exposure limit (1mg/m^3). The indoor related humidity ratio (RH) and indoor dry bulb temperature were 65%, 32 °C, respectively. Indoor air pollution was observed in this group after consecutively controlling the effects of indoor related humidity and indoor dry bulb temperature. Due to the design of the current cross-sectional nature, causal inferences cannot be made. The limitations of design and measurement are discussed in the context of the workplaces assessment field.

Key words: Dust · Particulate Matters · Bakery · Air Pollution · Occupational Safety

INTRODUCTION

Occupational exposure to flour occurs mainly in occupations in bakeries, flour mills, other food-producing and processing industries, as well as related industries such as enzyme-producing and baking-ingredient industries. Many of these bakeries are increasingly located in small-scale enterprises and supermarkets in Iran. Although exposure to inhalable flour dust and allergens among bakery workers has been very well documented. There are no exposure assessments studies reported of workers in bakeries within the Iranian academic publications.

Considering the extensive use of cereals and breads made from grain flour in 4 to 25% of people exposed to allergic reactions from consumption of grain or flour dust contact with it can be seen at least 40 allergenic proteins in the flour prepared in wheat. There are two main classified solutions as (albumin and globulin) and insoluble in water (gliadin and glutenin) [2]. The results of other similar studies, research suggests that in addition to section albumin is the main cause of allergies and asthma (Baker's asthma) inhaling or consumption Golbadin leading to the enhance of the antibody specific serum and increased allergies, respiratory disorders and ultimately "Asthma" [1, 2].

Baker's asthma due to airborne allergens present in flour dust in the work environment is one of the most commonly reported manifestations of worldwide occupational asthma [3]. Assessment flour dust pollution in the workshops bakery and side products that somehow deal with the flour dust in terms of health care for workers. The defined results are important and it's outcome may improve the quality of workers' knowledge in order to prevent respiratory diseases caused by the exposure of dust flour [4, 5]. In this work, according to geographical location and previous investigations involved different factors such as culture, job status, safe and healthy workplaces are investigated. Numerous studies have evaluated exposure to flour dust among bakery workers [4]. Most of these studies have been conducted in industrial bakeries, where the differences in exposure

Corresponding Author: Seyedtaghi Mirmohammadi, Department of Occupational Health, Faculty of Health, Mazandaran University of Medical Sciences, Sari, Iran. Tel: +981513543617, E-mails: seyedtaghim@gmail.com & mirtaghim@yahoo.com.

between job titles and tasks are more distinct. In relation to bakers, results of these studies demonstrated that workers at the front end of the baking process (dough makers, bread formers) have the highest 8-hour average or Time Weighted Average (TWA) dust exposures (average inhalable dust exposures of 3-9 mg/m^3) [6].

METHODS AND MATERIALS

Bakeries Details: Sampling methods was based on personal long-term exposure. All samples were collected in the workers' breathing zone using IOM sampling heads with polytetra fluoro ethylene filters (PTFE Membrane, SKC) with 2µm pore size. In order to have fixed flow rate of 2 L/min, the SKC sampler pump was calibrated by film flow meter soap device. Field blanks were included for each sampling visit. For each gravimetric stage, the filters were weighted twice in a preconditioned room (kept at constant temperature and humidity) before and after sampling were undertaken and the personal dust exposure [8 h TWA (mg/m^3)] calculated. Eighty bakeries work stations from north of Iran (Health and Safety Executive and Local Authority inspected) were sampled for the time duration of November 2010 to March 2011. Workers were randomly selected from different areas of the bakery where flour products were used.

Analytical Method: A 25mm, 2µm pore size poly tetra fluoro ethylene (PTFE) filter with support ring is used as the filtration medium. The filter was supported by a stainless steel screen that is supplied with the personal environmental monitor. In the laboratory, the weighing room was set on 22°C and 40% as a permissible temperature and relative humidity, respectively. The SKC Leland Legacy pump (UK) was calibrated with a soap film flow meter in the laboratory at 2 liters per minute (± 5%) and distributed among the workers for personal sampling.

After sampling all the PTFE filters were stored in a laboratory refrigerator at 41°C until they were analyzed (storage duration was 90 days). Samples were analyzed in a same time in the study laboratory. Gravimetric technique was used to analyze the PTFE filters. Filters were weighted using a Sartorius ME 5 (Sartorius AG, Gottingen, Germany) laboratory microbalance after equilibration in a weighting room where temperature and relative humidity were checked. Basically, the procedure of gravimetric technique is calculating the average sample mass by taking the difference of the average post weight and average pre weight.

Statistical Methods: To calculate determinants of flour dust exposure, analysis was performed using a linear mixed-effects regression model with fixed effects for covariates (such as relative humidity, dry bulb temperature, bakery size, job task, type of bakery). The SPSS software (Statistical Package for Social Scientists V20, SPSS Inc.) was used for the data analysis for the occupational hygiene reports. In present study, descriptive statistical analysis was performed for the obtained data. One-way ANOVA and correlation were used to compare exposures for bakers classified by pollution and job task [14].

Based on indoor air quality research results were studied on relationship level between meteorological factors and air pollution concentrations [15]. They used a general regression equation, which has three independent variables and one dependent variable, as equation is stated as follows:

$$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + e$$

where a is the constant of regression and b is the coefficient of regression. Each coefficient b represents the effect of the independent variable on y.

The data of logarithm of interior concentration (ln C, µg/m^3), interior temperature (T, °C), interior humidity (H, %) and days of work (D, days) at each air sampling were fitted simultaneously to the following equation and the parameters (A, B_1, B_2 and B_3) were estimated by a linear least-squares correlation for each compound. Data analyses were performed using the software STATISTICA resulting in following Equation:

$$\ln C = B_0 + B_1.T + B_2.\ RH$$

where A is the intercept of the regression line; B1 and B2 are regression coefficients related to the interior temperature (T) and interior humidity (H), respectively [16].

RESULTS

During the curse of investigation, eighty full-shift personal samples were collected. Table 1 present the results for the flour-dust concentrations in different bakeries workplaces. Sampling was performed by positioning an IOM open face (25mm) sampler at near breathing zone height. The other parameters (such as dry bulb temperature, workplace shop and relative humidity) were measured for all bakeries work stations.

Table 1: Values of indoor air parameters in the Pollutant concentration

Bakeries code					
Variables		I	T	M	Average
Pollution Concentration (mg/m^3),	Max	32	31	33	32
	Min	19	23	21	21
	Mean	28	26	30	28

Table 2: The result of Pollutant concentration correlation and indoor parameters (RH)

		Pollutant Concentration (mg/m^3)	RH (%)
RH (%)	Pearson Correlation	0.925	1
	Sig. (2-tailed)	0.0001	.
	N	80	80

Correlation is significant at the 0.05 level (2-tailed).

Table 4: The result of Pollutant concentration correlation and indoor parameters (Td)

		Pollutant Concentration (mg/m^3)	Td (°C)
Td (°C)	Pearson Correlation	0.911	1
	Sig. (2-tailed)	0.0001	.
	N	80	80

Correlation is significant at the 0.05 level (2-tailed).

Table 5: The result of Pollutant concentration correlation and indoor parameters (D)

		Pollutant Concentration (mg/m^3)	D (m^3)
D (m^3)	Pearson Correlation	-0.974	1
	Sig. (2-tailed)	0.0001	.
	N	80	80

Correlation is significant at the 0.05 level (2-tailed).

The bakeries were divided in 3 groups: industrial (I), traditional (T) and mixed (M) in Table 1.

Descriptive statistical analysis for indoor air variables is summarized in Table 1 with respect to inhalable flour dust (pollutant) concentration in the bakeries. Maximum pollutant concentration was 32 mg/m^3 and minimum pollutant concentration was 21 mg/m^3. These values can be considered as high, compared to NIOSH permissible exposure limit value (1 mg/m^3). The mean Pollutant concentration was 28 mg/m^3.

The lowest mean pollutant concentration (21 mg/m^3) was observed in bakeries which have the biggest size 350 m^3. Conversely, the highest means pollutant concentration of 32 mg/m^3 was observed in small workplace.

Correlation Between Pollutant and Indoor Air Variables: For better understanding of behavior of such particulates matter in the study workplaces, multivariable regression model was used to determine the correlation among dependent and independent variables. The results showed that three parameters are strongly correlated with pollutant concentration (mg/m^3) as dependent variable at 0.05 level, 2-tailed ($P < 0.05$) (Tables 2-5).

The constant coefficients related to dry bulb temperature, relative humidity and shop size. The independent variables (dry bulb temperature, relative humidity and workplace size) were obtained for the model to get the regression coefficients for pollutant concentration in the bakeries.

Multicollinearity refers to linear inter-correlation among psychrometric variables. If psychrometric variables (relative humidity, dry bulb temperature and dimension of workplaces) highly correlated they are redundant in the same model. The best regression models are those in which the predictor variables each is highly correlated with the dependent (outcome) variable but correlated at most only minimally with each other (see Table 6).

$$y = 15.11 + 0.25\ Td + 0.11\ RH - 0.041\ S$$

The above equation implies that dry bulb temperature and relative humidity affects inhalable particulate matters concentration in the work places. The results of the summary entail that two of parameters (dry bulb temperature and relative humidity) can be significant predictors of pollutant concentration condition in the bakeries workplaces.

Table 6: Collinearity statistical model coefficients

	Coefficients				Collinearity Statistics	
	B	SE	t	P value	Tolerance	VIF
(Constant)	27.771	2.638	10.528	0.0001		
Relative humidity (%)	0.368	0.067	5.454	0.0001	0.592	1.689
Dry bulb temperature (°C)	1.492	0.119	12.588	0.0001	0.592	1.689

a Dependent Variable: Pollutant Concentration (mg/m^3)

DISCUSSION

This study demonstrates that bakers have the highest 8-hour average dust exposures, compared with confectioners. The average inhalable flour dust exposures for the bakery workers in this study among workers in industrial and traditional bakeries (20 mg/m^3) was higher than the levels reported by other researchers (2.2-4.7 mg/m^3) [7], (0.56- 2.10 mg/m^3) [8] and (0.7-4.5 mg/m^3) [9]. More importantly, job titles associated with high particulate matters levels in present work are consistent with almost all other studies reported in literature.

In this study, as a well documented findings full-shift inhalable dust exposures observed tended to be somewhat higher than those reported by other investigators [7-9]. Compare to other studies, present research illustrates to have high mean exposure and high percentage of the exposures above 20 mg/m^3. Traditional bakeries were exposed to higher concentrations of inhalable dust than those involved in other type production that was due to poor ventilation or non-appropriated design of work area. Full-shift inhalable dust exposure in industrial ventilated bakeries was higher than that in without any system; it may be due to high production capacity, variety of cooking stove and workers. There was a high level of pollution in winter (cool weather, 18- 25°C) compared to autumn (moderate weather, 26- 32 °C) in assessed bakeries. The results of present study has illustrated that all kind of bakeries (industrial, traditional and mixed) have the maximum mean concentration of inhalable flour dust particulate compare to threshold limit value (1 mg/m^3).

In other survey observed that silo and bin cleaning tasks resulted in maximum dust exposures but there were no cleaning tasks in this study. For other parameters, use of local exhaust ventilation systems in bakeries has not been stated in literature [10]. Absence or non perfect local of exhaust ventilation in the assessed bakeries made it impossible to use our data in assessing its effectiveness in controlling inhalable flour dust exposure [10]. The mean inhalable flour dust exposures of this group of bakery workers were lower than the levels reported by others [11] and among workers in industrial (19–25 mg/m^3) and traditional bakeries (26–33 mg/m^3). But that was comparable to levels reported by other researchers [11-13]. Also the mean dust exposure levels in this research were similar to those reported by other researchers in UK bakeries [13].

There are presently specific exposure limits for wheat dust in Iran; while an occupational exposure limit of 20 µg/m^3 is suggested. When using this result, the common flour dust sample concentrations exceeded this limit value, it is clear that bakery workers are not safe and adequately protected against the allergic health risk associated with flour dust if the current legal standards are applied.

Results of dry bulb temperature, relative humidity and shop size were associated with significantly increased exposures, but other parameters such as ventilation, working time and kind of bread were not significant. The obtained results in this work supported by the results of multiple regression modeling. Two factors, dry bulb temperature and relative humidity increasing and shop size decreasing time weighted average inhalable dust exposure in the bakeries. One of the most important factors increasing TWA inhalable dust exposure was time spent pouring or dusting in the workplaces. Clearly, decreasing time spent pouring, dusting and weighing flour should reduce exposure.

CONCLUSION

This pilot study of exposure characterization among bakery workers in Iran is one of kind of studies conducted in workplaces. These outcomes showed that there is serious needs to have these legal exposure standards revised. The results of this cross-sectional study will be used to optimize the control strategy for the larger and more detailed baseline exposure assessment study to flour dust and flour allergens in bakeries of these shops.

AKNOWLEDGEMENT

Present work was funded by Mazandaran University of Medical Sciences. Author would like to thank the members of the Field Scientific Support Unit at assistant of Health Executive (in particular Engineers M. Asadi and R. Panahi and S.E. Rashidaei) for their help with the organization and conduction of study, date collection and completion of the occupational hygiene reports.

REFERENCES

1. Bogdanovic, J., I. Wouters, I. Sander, M. Raulf- Heimsoth, J. Elms, M. Rodrigo, D. Heederik and G. Doekes, 2006. Airborne exposure to wheat allergens: measurement by human immunoglobulin G4 and rabbit immunoglobulin G immunoassays. Clinical and Experimental Allergy, 36(9): 1168-1175.

2. Brant, A., J. Berriman, C. Sharp, J. Welch, C. Zekveld, M. Nieuwenhuijsen, J. Elms, A. Newman-Taylor and P. Cullinan, 2005. The changing distribution of occupational asthma: a survey of supermarket bakery workers. European Respiratory Journal, 25(2): 303-308.
3. Jeebhay, M. and S. Quirce, 2007. Occupational asthma in the developing and industrialised world: a review [State of the Art Series. Occupational lung disease in high-and low-income countries, Edited by M. Chan-Yeung. Number 1 in the series]. The international journal of tuberculosis and lung disease, 11(2): 122-133.
4. Cullinan, P., A. Cook, M.J. Nieuwenhuijsen, C. Sandiford, R.D. Tee, K.M. Venables, J.C. McDonald and A.J.N. Taylor, 2001. Allergen and dust exposure as determinants of work-related symptoms and sensitization in a cohort of flour-exposed workers; a case control analysis. Annals of Occupational Hygiene, 45(2): 97-103.
5. Elms, J., E. Robinson, H. Mason, S. Iqbal, A. Garrod and G. Evans, 2006. Enzyme exposure in the British baking industry. Annals of Occupational Hygiene, 50(4): 379-384.
6. Heederik, D. and A.J. Newman-Taylor, 2006. Occupational asthma in the baking industry. In: I.L. Bernstein, M. Chan-Yeung, J.L. Malo and D.I. Bernstein, eds. Asthma in the Workplace, 3rd ed. New York: Taylor and Francis, 17: 393-414.
7. Elms, J., E. Robinson, S. Rahman and A. Garrod, 2005. Exposure to flour dust in UK bakeries: current use of control measures. Annals of Occupational Hygiene, 49(1): 85-91.
8. Bulat, P., K. Myny, L. Braeckman, M. Van Sprundel, E. Kusters, G. Doekes, K. Possel, J. Droste and M. Vanhoorne, 2004. Exposure to inhalable dust, wheat flour and α-amylase allergens in industrial and traditional bakeries. Annals of Occupational Hygiene, 48(1): 57-63.
9. Houba, R., D. Heederik and H. Kromhout, 1997. Grouping strategies for exposure to inhalable dust, wheat allergens and Î±-amylase allergens in bakeries. Annals of Occupational Hygiene, 41(3): 287-296.
10. Kromhout, H., P. Swuste and J.A.N.S.M. Boleij, 1994. Empirical modelling of chemical exposure in the rubber-manufacturing industry. Annals of Occupational Hygiene, 38(1): 3-22.
11. Meijster, T., E. Tielemans and D. Heederik, 2009. Effect of an intervention aimed at reducing the risk of allergic respiratory disease in bakers: change in flour dust and fungal alpha-amylase levels. Occupational and environmental medicine, 66(8): 543-549.
12. Brant, A., J. Berriman, C. Sharp, J. Welch, C. Zekveld, M. Nieuwenhuijsen, J. Elms, A. Newman-Taylor and P. Cullinan, 2005. The changing distribution of occupational asthma: a survey of supermarket bakery workers. European Respiratory Journal, 25(2): 303-308.
13. Elms, J., E. Robinson, S. Rahman and A. Garrod, 2005. Exposure to flour dust in UK bakeries: current use of control measures. Annals of Occupational Hygiene, 49(1): 85-91.
14. Mirtaghi Mirmohammadi, M., A. Hakimi, Ahmad M. Mohammadyan and K. Kamel, 2010. Evaluation of Indoor Air Pollution of Polyurethane Industries with Emphasis on Exposure with Methylene Diphenyle Diisocyanate (MDI). Iranica Journal of Energy and Environment, 1(2): 100-105.
15. Mirtaghi Mirmohammadi, M. Hakimi, Ibrahim, Anees Ahmad, Abbas F.M. AlKarkhi, Norizan, Esa, Mohd. Omar Abdul Kadir, M. Mohammadyan and S.B. Mirashrafi, 2009. Indoor Air Pollution Study on Toluene Diisocyanate (TDI) and Biological Assessment of Toluene Diamine (TDA) in the Polyurethane Industries. World Applied Sciences Journal, 6(2): 242-247.
16. Yoshida, Toshiaki and Matsunaga, Ichiro, 2007. A case study on identification of airborne organic compounds and time courses of their concentrations in the cabin of a new car for private use. Environment International, 33(2): 275-281.