INTRODUCTION

Occupational lung diseases are a group of illnesses that are caused by either repeated, extended exposure or a single, severe exposure to irritating or toxic substances that leads to acute or chronic respiratory ailments ***(American Lung Association, 2010).***

Occupational diseases are caused by a pathologic response of the patients to their working environment ***(Imbus, 1994).***There is growing consensus on the deleterious effects of organic dust on respiratory symptoms and functions of industrial workers ***(Kolopp-Sarda et al., 1994).***

Many studies have shown that flour dust exposure causes respiratory symptoms and is associated with impairment of lung function ***(Burstyn et al., 1997).*** A threshold limit value of 0.5 mg/m3 of flour dust was proposed in 2009 by the American Conference of Governmental Industrial Hygienists (ACGIH) as the occupational exposure level (OEL) in breathing zones for workers in flour mills ***(ACGIH, 2009).***

Flour dust is widely incriminated to cause such effects. Exposure to flour dust occurs across a range of food industries including grain mills, flour mills and bakeries. ***(Kolopp-Sarda et al., 1994).***

Wheat flour is a complex organic dust with a large diversity of antigenic or allergenic components. The antigens involved can be wheat flour proteins, flour parasites or technical additives ***(Kolopp-Sarda et al., 1994).***

Wheat flour consists of water-soluble albumins, salt-soluble globulins, gliadins and glutens. Albumins and globulins appear to be the most important proteins contributing to immediate hypersensitivity reactions to wheat proteins ***(James et al., 1997).***

Flour dust is an asthmagen and is known to cause sensitization, allergic rhinitis and occupational asthma amongst bakers and millers ***(Jeffrey et al., 1999).***

Flour dust can also act as an irritant and may give rise to short-term respiratory, nasal and eye symptoms, or it may provoke an asthma attack in individuals with pre-existing disease. In the UK, for example, flour and grain dust are the second most commonly cited agents associated with occupational asthma ***(Ross et al., 1997).***

The respiratory effects of exposure to flour dust are influenced by the dose and duration of exposure ***(Shamssain, 1995).*** And these differ from one work environment to another. Therefore, it may not be correct to extrapolate the results of studies conducted in a different environment to our bakeries ***(Elms, 2003).***

Unhygienic conditions are observed in the workplace environment of flour mills as fine organic flour dust gets airborne in the indoor environment of the flour mills. The results of previous study show that flour mill workers are receiving a heavy dose (average exposure concentration, 624 $\mu g/m^3$) of flour dust, to determine the impact of flour dust on the lung function of the workers spirometric analysis was conducted. Significant declines in forced vital capacity (FVC), peak expiratory flow rate (PEFR) and forced expiratory volume in one second (FEV1) were observed. The analysis of questionnaires reveals that most of the workers were suffering from asthma and respiratory problems ***(Wagh et al., 2006).***

This previous study recommends the compulsory use of personal protective equipment (nose mask) by flour mill workers during working hours. This would help to protect the workers' health from the flour dust prevalent in the workplace environment. A regular periodic examination is necessary to measure the impact of particulate matter on the health of the flour mill workers ***(Wagh et al., 2006).***

Lung function tests are beneficial in the early recognition of pulmonary dysfunctions even if the workers may be normal clinically ***(Cotes, 1979).***

Aim of the Work

The aim of this study is to assess the effects of exposure to flour dust on respiratory symptoms and lung function of bakery workers at a number of bakeries in Cairo.

SUBSTANCE IDENTIFICATION

Airborne contaminants can occur in the gaseous form (gases and vapours) or as aerosols, which include airborne dusts, sprays, mists, smokes and fumes ***(WHO report,1999).***

Airborne dusts are of particular concern because they are associated with classical widespread occupational lung diseases such as the pneumoconioses, as well as with systemic intoxications such as lead poisoning, especially at higher levels of exposure ***(WHO report,1999).***

There is also increasing interest in other dust-related diseases, such as cancer, asthma, allergic alveolitis and irritation, as well as a whole range of non-respiratory illnesses, which may occur at much lower exposure levels ***(WHO report,1999).***

Whenever people inhale airborne dust at work, they are at risk of occupational disease. Year after year, both in developed and in developing countries, overexposure to dusts causes disease, temporary and permanent disabilities and deaths. Dusts in the workplace may also contaminate or reduce the quality of products, be the cause of fire and explosion, and damage the environment ***(WHO report,1999).***

As a matter of social justice, human suffering related to work is unacceptable. Moreover, appreciable financial losses result from the burden of occupational and work related diseases on national health and social security systems, as well as from their negative influence on production and quality of products. All these adverse consequences, which are economically costly to employers and to society, are preventable through measures which have been known for a long time, and which are often of low cost ***(WHO report,1999).***

Definitions and examples:

Dusts are solid particles ranging in size from below 1 µm up to around 100 µm, which may be or become airborne, depending on their origin, physical characteristics and ambient conditions.

Examples of hazardous dusts in the workplace include:

* Mineral dusts from the extraction and processing of minerals (these often contain silica, which is particularly dangerous);

* Metallic dusts, such as lead and cadmium and their compounds;

* Other chemical dusts, such as bulk chemicals and pesticides;

* Vegetable dusts, such as wood, flour, cotton and tea, and pollens;

* Moulds and spores.

Asbestos is a mineral fibre, which is particularly dangerous, and is found, for example, in maintenance and demolition of buildings where it had been used as insulation material ***(WHO report,1999).***

Size fractions:

In occupational hygiene, particle size is usually described in terms of the aerodynamic diameter, which is a measure of the particle's aerodynamic properties. Whether or not an airborne particle is inhaled depends on its aerodynamic diameter, the velocity of the surrounding air, and the persons' breathing rate. How particles then proceed through the respiratory tract to the different regions of the lungs, and where they are likely to deposit, depend on the particle aerodynamic diameter, the airway dimensions and the breathing pattern. If a particle is soluble, it may dissolve wherever it deposits, and its components may then reach the blood stream and other organs and cause disease. This is the case, for example, of certain systemic poisons such as lead. There are particles which do not dissolve, but cause local reactions leading to disease; in this instance, the site of deposition makes a difference. When a relatively large particle (say 30 μm) is inhaled, it is usually deposited in the nose or upper airways. Finer particles may reach the gas-exchange region in the depths of the lungs, where removal mechanisms are less efficient, Certain substances, if deposited in this region, can cause serious disease, for example, crystalline silica dust can cause silicosis. ***(WHO report,1999).***

The smaller the aerodynamic diameter, the greater the probability that a particle will penetrate deep into the respiratory tract. Particles with an aerodynamic diameter > 10 µm are very unlikely to reach the gas-exchange region of the lung, but below that size, the proportion reaching the gas exchange region increases down to about 2 mm ***(WHO report,1999).***

The depth of penetration of fibers into the lung depends mainly on its diameter, not its length. As a consequence, fibers long as 100 µm, have been found in the pulmonary spaces of the respiratory system ***(WHO report,1999).***

Whenever exposure to airborne dust needs to be quantitatively evaluated, instruments must be used which select the right size range for the hazard concerned. There are conventions for the size ranges of particles to be measured; it is usual to collect either the inhalable fraction, i.e. everything that is likely to be inhaled, or the respirable fraction, i.e. the particles likely to reach the gas-exchange region of the lung. For example, if silica is present, it is necessary to measure the respirable fraction of the airborne dust ***(WHO report,1999).***

Dust generation:

Mineral dusts are generated from parent rocks by any breaking down process, and vegetable dusts are produced by any dry treatment ***(WHO report,1999).***

The amount, hence the airborne concentration, is likely to depend on the energy put into the process. Air movement around, into or out of granular or powdered material will disperse dust. Therefore handling methods for bulk materials, such as filling and emptying bags or transferring materials from one place to another, may constitute appreciable dust sources. Coarse materials usually have a dust-sized component as a result of attrition. If dust clouds are seen in the air, it is almost certain that dust of potentially hazardous sizes is present. However, even if no dust cloud is visible, there may still be dangerous concentrations of dust present with a particle size invisible to the naked eye under normal lighting conditions ***(WHO report, 1999).***

Unless its generation is prevented or it is removed from the air, dust may move with ambient air and reach even persons who are remote from the source and whose exposure is unsuspected. Damp materials are less likely to release airborne dust, but of course this does not apply if they dry up later ***(WHO report,1999).***

Sources of exposure:

Work processes likely to generate dust include the following:

* Mining, quarrying, tunnelling, stone masonry, construction, and any process which breaks or separates solid material.

* Foundries and other metallurgical processes, especially the cleaning of casting and breaking of moulds.

* Any process using abrasive blasting, such removal of paint and rust, cleaning of buildings and small objects, and etching of glass.

* Manufacture of glass and ceramics.

* Handling of powdered chemicals in the chemical, pesticide, rubber manufacturing and pharmaceutical industries.

* Agricultural work involving exposure to soil, intensive animal husbandry, dry vegetable products, or agro-chemicals.

* Food processing, especially where flour is used.

* Any process involving weighing, bagging, bag-emptying or dry transport of powdered or friable materials. ***(WHO report, 1999).***

Flour dust refers to dust coming from finely milled or otherwise processed cereal. Hypersensitivity reactions as well as irritant symptoms caused by flour dust constitute a well-recognized occupational problem world-wide. Most data on flour dusts have been derived from studies on wheat (Triticum sp.) and rye (Secale cereale), and to a lesser extent on barley (Hordeum sp.) and oats (Avenea sativa). From the point of view of hazard assessment, all these taxonomically related cereals, belonging to the family Poaceae, are relevant. The allergens they contain have been shown to cross-react with each other, indicating that these allergens are common to different ***(SCOEL, 2008).***

The flour dust in the bakery industry may contain several other non-cereal components, so called dough-improvers, such as a variety of enzymes (e.g. α-amylase of various origin, malt enzymes, cellulase, hemi-cellulase, xylanase), chemical ingredients (e.g. preservatives, bleaching agents, antioxidants), flavourings, spices, and other additives (e.g. baker's yeast, egg powder, sugar) as well as contaminants such as storage-related mites and microbes ***(Tiikkainen et al., 1996).*** Several of these components are sensitizers. α-Amylase is an important sensitizer small amounts of which (0.1 to 1.0 mg/ g flour) are naturally present in wheat ***(Jauhiainen et al., 1993; Burdorf et al., 1994).***

Physical and biochemical properties:

Wheat is the primary cereal grain used in bread making. Seeds are composed of endosperm (85%), husk (13%) and germ

(2%). The milling process separates the endosperm from husk and germ and reduces the particle size of the endosperm. Wheat flour is made from the endosperm. This wheat flour contains starch and four different groups of proteins (water soluble albumins, globulins, prolamins (gliadin), and glutelins (glutenin)). Both gliadins and glutenins form viscous complexes, called gluten, which determine the structure and texture of bread to a great extent. ***(SCOEL, 2008).***

The proteins present in flour dust are potential allergens. The strongest allergic potency has been observed with water-soluble albumin fractions in vitro ***(Prichard et al., 1985),*** but the allergic potency of gliadin, globulin and glutenin protein fractions should not be ruled out ***(Walsh et al., 1985) .*** The number of potent dust flour allergens from these four protein fractions is large. In one study, 40 different allergens were identified by crossed immuno-electrophoresis ***(Blands et al., 1976). Sander et al.,*** reported that each patient showed an individual IgE-binding pattern with 4 to 50 different protein spots in the immunoblots ***(Sander et al., 2001).***

The IgE-antibodies in sensitized reacted with several of these flour allergens, although individual reaction profiles showed large variability ***(Sutton et al., 1984).***

The molecular weights of identified flour allergens vary between 12-64 kDa ***(Sandiford et al., 1994 "b").*** The major allergens (about 15 kDa) of flours belong to the group of the α-amylase inhibitors ***(Fränken et al., 1994)*** which prevent insect α-amylases from harming the cereal. The 3 glycosylated forms of these proteins have been suggested to be the most potent allergens ***(Sanchez-Monge et al., 1992).***

The allergen content of the dust can be evaluated by recently developed immunoassays ,in which allergens bind to specific antibodies. ***(Sandiford et al.,1994a)*** developed a method for measuring airborne wheat flour allergens in bakeries and flour mills, using polyclonal rabbit IgG-antibodies in a Radio-Allergo-Sorbent-Test (RAST) whereas ***(Houba et al., 1996a)*** used an anti-wheat IgG4 serum pool from bakery workers in an Enzyme- Linked Immuno-Sorbent Assay (ELISA). Both methods measure the total spectrum of allergens in wheat flour. A method more specific for one of the major allergens in wheat flour, the 15 kDa alpha-amylase inhibitor protein, uses monoclonal antibodies ***(Wiley, 1997).*** These techniques are not yet standardised for routine monitoring. ***(Sandiford et al., 1994a; Houba et al., 1996a; Wiley, 1997).***

Airborne flour dust particle sizes have been measured by several investigators. ***Lillienberg and Brisman (1994)*** showed a bimodal distribution of aerodynamic diameters of flour dust, using an IOM dust spectrometer. The smallest particles were around 5 µm, and the bigger ones around 15-30 µm. Over 50% of the particle mass had an aerodynamic diameter over 15 µm. ***(Lillienberg and Brisman, 1994)***. Using the IOM personal inspirable aerosol spectrometer, **(*Burdorf et al., 1994)*** estimated that the thoracic fraction contributed 39% to the total mass of inhalable dust, The respirable fraction (particles ≤4) amounted to 19%. **(*Sandiford et al., 1994c)*** measured that approximately 9%, 52% and 20% of the airborne flour proteins were borne on particles 6 µm diameter in the bakery dough-brake, bakery roll-production and in the flour mill-packing areas, respectively. **(*Sandiford et al., 1994c).***

The location where flour dust particles will most likely deposit is influenced by several factors. The particles' size, density, shape, aerodynamic properties, as well as the volume of respiration determine the deposition of the particles in the lung. In general, particles having an aerodynamic diameter of 5 to 30 µm are deposited in the naso-pharyngeal region. Particles with lower aerodynamic diameters are deposited in the trachea, bronchial and bronchiolar region or in the alveolar region (≤ 1 µm). ***(ACGIH ,1999)*** uses the terms inhalable (≥10 µm, 100 µm cut-point), thoracic (4 -10 µm) and respirable (≤ 4 µm) particulate mass for Threshold Limit Values for particulates that may be hazardous when inhaled. Substantial amounts of flour