BAKERS' ALLERGY AND ASTHMA – TOWARDS PREVENTIVE STRATEGIES

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INTRODUCTION

Occupational allergies are generally regarded as diseases resulting from a hypersensitivity (exaggerated response) of the immune system to substances encountered in the work environment.[1] Bakers' asthma, like other forms of occupational asthma, is probably the most serious manifestation of occupational allergy among bakery workers.[2] It is caused by immunological sensitisation and subsequent allergic reaction in the airways to specific occupational airborne allergens present in flour or the ingredients of the baking process. Less severe types of bakers' allergy are rhinitis (with frequent sneezing, nasal obstruction, and rhinorrhoea), conjunctivitis (with itching and inflamed red eyes) and dermatitis, e.g. urticaria.[2]

THE BAKING PROCESS AND HIGH-RISK ENVIRONMENTAL EXPOSURE SETTINGS

Occupational exposure to flour occurs mainly in environments like bakeries, flour mills, other food-producing and processing industries, and related industries such as enzyme-producing and baking-ingredient industries. Bread is not the exclusive product of modern baking industry. Other products such as cakes, biscuits and pastry, are made not only of flour, but also yeast, spices and additives. The production process includes sifting of flour, making dough, cutting and shaping, baking, cooling and storing. In the initial phases of this operation the concentration of flour dust increases tremendously. Flour and other ingredients used in the baking industry contain potent allergens that may induce sensitisation and/or cause bronchial hyperactivity, bronchial asthma and chronic obstructive bronchitis in workers.[3] Results of exposure studies demonstrate that workers at the front end of the process of baking (dough makers, bread formers) have the highest 8-hour average dust exposures (average inhalable dust exposures of 3 – 9 mg/m^3).[4] Among bread and cake baking groups, sieving gives rise to the greatest dust exposures, followed by weighing and mixing.[5] Furthermore cleaning operations, and bread and roll production also give rise to high exposures.[6] Most peak exposures are caused by dusting during dough forming (to prevent dough adhesion to surfaces) or by adding ingredients into the dough mixer. The relationship between dust and wheat antigen exposure varies considerably, depending on the specific bakery occupation, the size of the bakery, and the type of product produced by the bakery.[7]

CONSTITUENTS OF FLOUR DUST AND POTENTIAL ALLERGENS

Flour and its additives contain many potential allergens, which include components of wheat flour, flour contaminants such as mites, weevils and moulds. Well-known high-molecular-weight sensitisers are wheat proteins and baking additives such as enzymes (e.g. *Aspergillus*-derived fungal α-amylase.[8] The general consensus is that wheat flour and fungal α-amylase are usually the most important allergens (except in countries such as Germany where the widespread use of rye makes it a more common allergen). Table I lists potential allergens, including non-flour related products (Fig. 1), to which bakery workers may be exposed.

Table I. Potential occupational allergens causing bakers' allergy and asthma

Cereal flours
Wheat
Rye
Barley
Cereal malt flour
Rice flour

Non-cereal flours
Soybean flour
Buckwheat
Lecithin (from soybean)

Baking additive enzymes
α-amylase
Gluco-amylase
(Hemi) cellulase
Protease
Xylanase
Papain
Glucose oxidase

Moulds and yeast
Aspergillus, Alternaria
Bakers' yeast

Other additives
Egg material yolk
Egg white
Almond, hazelnuts
Cocoa
Milk powder
Sesame seeds
Chocolate

Insects
Storage mites
Grain weevil
Flour beetle
Cockroach
Flour moth

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Fig. 1. Addition of sesame seeds, a potential allergen in bread rolls.

EPIDEMIOLOGY OF ALLERGIC SENSITISATION AND ASTHMA ASSOCIATED WITH FLOUR DUST

It is well documented that exposure to flour dust increases the risk of allergic sensitisation and lung diseases, particularly occupational asthma.

Allergic sensitisation

Cereals

Most reports implicate cereal flours such as wheat flour (*Triticum* spp.), rye flour (*Secale cereale*) and barley flour (*Hordeum vulgare*) as agents responsible for allergic diseases in bakery workers.[2,10] The prevalence of sensitisation varied from 5% to 28% for wheat flour.[2] The incidence of sensitisation to flour is estimated to be 22 cases per 1 000 person-years (pyrs).[9]

Enzymes

Exposure to fungal α-amylase has been reported as a considerable health risk for the development of occupational asthma in British bakeries and flourmills.[10] Fungal α-amylase is routinely added to flour to hasten the baking process and improve bread quality. Several case reports have been documented of bakers' asthma caused by this enzyme, often in the absence of specific IgE to cereal allergens.[11–15] The prevalence of sensitisation varies between 2% and16% for fungal α-amylase. The incidence of sensitisation to fungal α-amylase is estimated to be 25 cases per 1 000 pyrs.[9]

Storage mites

Wheat flour in bakeries can be contaminated with storage mites, and allergens from storage mites have been suggested as another cause of allergic symptoms in bakery workers.[16] A number of epidemiological studies show a high prevalence of sensitisation to storage mites *(Acarus siro, Glycyphagus domesticus, Lepidoglyphus destructor, Tyrophagus longior,* and *Tyrophagus putrescentiae)* in bakery workers varying between 11% and 33%. Tee,[17] however, suggested that cross-reactivity with house-dust mite was the main reason for immunological reactivity to storage mites observed in bakery workers.

Respiratory symptoms and asthma

Studies conducted among bakery workers have documented prevalences of respiratory symptoms varying between 5% and 21%.[14,15,18,19] The reported prevalence of bronchial hyperresponsiveness ranges between 25% and 40%.[20–22] Studies among trainee bakers estimate incidence rates of 29.4 cases per 1 000 pyrs for rhinitis and 3 cases per 1 000 pyrs for asthma.[23] Incidence rates for bakers and millers have recently been estimated to be 118 cases per 1 000 pyrs for work-related eyes/nose symptoms and 41 cases per 1 000 pyrs for work-related chest symptoms. The incidence of work-related chest symptoms and a positive skin-prick test to flour or fungal α-amylase is 10 cases per 1 000 pyrs.[9]

DOSE-RESPONSE RELATIONSHIPS

The frequency of sensitisation to wheat flour and α-amylase tends to increase with intensity of both dust exposure and wheat allergen exposure.[14] A strong, statistically significant and positive association has been demonstrated between wheat flour allergen exposure and wheat-flour-specific sensitisation.[7] Similarly a strong and positive association has been found between allergen exposure levels and α-amylase specific allergic sensitisation.[24]

PREVENTION STRATEGIES FOR FLOUR DUST AND BAKER'S ASTHMA

Despite the overwhelming evidence that workplace exposures to flour dust should be controlled, prevention strategies in bakeries appear to have been very unsatisfactory. While there are exposure limits established, some are clearly inadequate and little regulatory action beyond general requirements has been applied to flour dust.[25]

Regulatory exposure standards

In the absence of specific regulatory exposure standards for allergens of biological origin, the only other standards of some relevance are the Regulations for Hazardous Chemical Substances (HCS) under the Occupational Health and Safety Act (OHSA). These regulations require regular environmental monitoring and medical surveillance of workers at high risk of developing adverse health effects as a result of exposure to respiratory sensitisers.[26,27] Grain dust has been designated a personal exposure control limit of 10 mg/m^3 TWA (total inhalable dust) and is denoted as a sensitiser (exposure should be prevented, especially activities giving rise to short-term peak concentrations). In addition to this standard being less conservative than international standards it is not directly applicable to bakery workers since the allergenicity of milled grain may be greater than unmilled grain.

The high sensitisation potential of grain dust makes the South African standard unacceptable in protecting the health of workers and is a source of concern. Studies have shown strong relationships between exposure to flour dust and health endpoints such as sensitisation and various work-related symptoms. These endpoints were observed at flour dust levels well below 10 mg/m^3.[9] Furthermore, there are no specific exposure limits for flour dust allergens such as wheat, rye and α-amylase in South African legislation.

In December 2001, the Regulations for Hazardous Biological Agents were promulgated in South Africa. However, the lack of emphasis on protein allergens causing allergic disease in the absence of microbial infections may point to the need for the development in the future of specific regulations that deal adequately and effectively with allergens of biological (protein) origin.[28]

The American Conference of Government Industrial Hygienists (ACGIH) have adopted a threshold limit value (TLV) of 0.5 mg/m^3 and in Holland the Dutch Expert Committee of the Health Council is working on a maximum allowed concentration (MAC), probably around 1 mg/m^3.[29–31]

Workplace interventions

Little information is available on the contribution of different determinants of exposure in the bakery industry (equipment, technology, and production layout). The high dust exposures that occur during the performance of bakery tasks (e.g. dough making) can be eliminated by fundamental modifications to the baking process and effective use of ventilation technology. General dilution ventilation has only a marginal effect on dust levels. The key element for dust control in bakeries is adequate *local exhaust ventilation.* Local ventilation should be concentrated to flour release points such as weighing stations, dough-making machines, dough brakes, and bread machines. Such ventilation could probably reduce dust exposures to concentrations below 1 mg/m^3.[32] Automation of parts of the process is a long-term option that could lead to considerably lower levels of exposure.[33]

Very few studies have demonstrated the effectiveness of *personal protective equipment* in respect of reducing exposure to high allergen loads in general and flour dust in particular.[34,35] The only case study report on flour dust and occupational asthma among two patients concluded that dust respirators were effective in preventing asthmatic reactions induced by buckwheat and wheat flour.[36]

Certain *work practices* to avoid flour dust becoming airborne include careful bag emptying and empty bag handling, and vacuum cleaning instead of using pressurised air. For certain products a *change in work practice* such as the use of divider oil can reduce exposures.[4] Use of divider oil to prevent dough adhesion has been associated with considerably lower exposures than dusting with flour (GM 0.43 mg/m^3 v. 12.0 mg/m^3 ; $p < 0.001$).[4] The introduction of new work practices requires that bakers be given adequate training for them to be effective.

Surveillance

Environmental exposure level monitoring

Environmental exposures need to be adequately monitored to assess effectiveness of intervention. Monitoring of dust as opposed to allergen levels has its limitations in that dust levels may only partially correlate with the actual allergen concentrations. Furthermore, it is questionable whether dust levels are a valid exposure parameter in occupations where IgE-mediated allergies predominate. Studies show that the correlation between concentrations of dust and wheat allergen is moderate, and poor for fungal α-amylase.[37]

Medical surveillance

The most widely used methods for medical screening and surveillance of occupational allergic respiratory diseases are questionnaires, spirometry and immunological tests.[38] Medical surveillance to detect occupational asthma at an early stage and remove sensitised workers has been implemented in some workplaces where there is an exposure to known workplace sensitisers. The aim is to detect immunological sensitisation or occupational asthma early, before it becomes severe or irreversible.[39] The methacholine challenge test has become the most widely used method of evaluating the likelihood that a given patient's respiratory symptoms represent asthma.[40] The use of skin-prick testing and specific IgE for workers exposed to flour allergens has also been shown to have good predictive value.[39] The combination of: (i) clinical history of suggestive of work-related asthma; (ii) documented asthma or airway hyperresponsiveness; and (iii) immunological evidence of sensitisation may therefore be adequately predictive of confirmation of occupational asthma by specific bronchial challenge testing.[41]

Managing the individual with bakers' asthma

As in other forms of allergic asthma, the management of choice for the classic type of bakers' asthma with sensitisation is allergen avoidance. This can be achieved by technical dust control, relocation of the baker to a less exposed job task, or by having the baker wear respiratory protection.[32] Because of the abundance of dust in most bakeries in relation to the minute allergen exposure needed to elicit symptoms in sensitised workers, change of employment is often necessary. Respirators are in most instances not well tolerated by bakers because of the heat in bakeries and the hinderance to physical activity. They also cause discomfort when worn for long periods. Immunotherapy with flour has been reported to be successful in bakers' asthma but needs further evaluation.[42,43] The treatment of bakers' asthma is no different from general asthma. Under South African law, there are also certain legal obligations on the medical practitioner diagnosing bakers' allergy and asthma. The Occupational Health and Safety Act (OHSA) makes it obligatory for medical practitioners to report all cases of suspected occupational disease to the Chief Inspector in the Department of Labour. Further a worker's compensation claim must be initiated following the procedures as outlined under the Compensation for Occupational Injuries and Diseases Act (COIDA).[44]

A Scandinavian workshop on the prevention of bakers' occupational diseases made the following recommendations on medical screening, surveillance and individual case management:[32]

- Asthmatics sensitised to flour or fungal α-amylase should change to non-bakery work.
- Asthmatics without sensitisation to flour or fungal α-amylase should be relocated to less exposed bakery tasks.
- Bakers with rhinitis and sensitisation should be investigated closely and relocation to less exposed tasks should be considered.
- Bakers sensitised to flour or fungal α-amylase but without respiratory symptoms should be re-examined annually.
- Bakers with rhinitis only but without sensitisation to bakery allergens do not warrant re-examination unless symptoms worsen.

CONCLUSION

Occupational asthma and rhinitis caused by allergens encountered in bakeries is an important occupational health problem that shows no signs of abatement. The medical, financial and social prospects for those with bakers' asthma are poor. Only concerted action is likely to substantially reduce ill health in bakeries, flourmills and other places where flour is used. Knowledge of disease endpoints, competence and skills to prevent them, and the provision of information for those at risk are essential, as are employer compliance and enforcement of the law.

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