

Allergy to flour and fungal amylase in bakery workers

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The purpose of this study was to describe the prevalence of respiratory symptoms and skin prick test findings in a group of 383 employees in a plant bakery population who had the greatest regular exposure to ingredient dusts. The prevalence of positive skin prick tests to fungal amylase was 16%, in contrast to 6% to wheat flour, suggesting that the principal sensitiser is fungal amylase and not flour. Furthermore, the findings suggest that symptomatic allergy to bread-baking ingredients is uncommon (3.1%). In comparison, occasional short-lived symptoms which do not appear to have an allergic aetiology are relatively prevalent (17.2%). Where sensitisation to ingredients arises, fungal amylase present in bread improvers is the principal allergen.

Key words: Amylase; asthma; bakers; flour.

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INTRODUCTION

Although asthma in bakers is a generally accepted phenomenon, the nature of the allergen or allergens responsible has been subject to much conjecture. Flour alone is thought to contain some 40 different potential allergens.¹ Whilst allergy to flour dust has been recognized for many years, the first report of sensitisation to amylase derived from *Aspergillus oryzae* in bakery workers did not appear until 1986.² Since then, interest in this agent as an important cause of allergic asthma and rhinitis has grown.^{3–8}

Fungal amylase has been used as an additive in the bread-making process for some 30 years. Indeed it has become an important ingredient which ensures consistent proving of the dough. Exposure in the bakery can arise from two possible sources. The principal source is bread improver which contains fungal amylase at a typical concentration by weight of 0.025–0.055%. A secondary source of exposure is from flour itself. Fungal amylase is added to certain wheat flours during the milling process in order to enhance the native cereal amylase activity. In this case, typical concentrations by weight of fungal amylase in the flour will be of the order of 0.000125%.

Whilst the materials used in the bread-making process have remained relatively unchanged over a number of

years, the patterns of exposure to these materials in large plant bakeries have. Unlike small craft bakeries, which handle ingredients in bagged form, modern plant bakeries take a number of ingredients which are used in large volumes, in bulk form. Essentially this means that these ingredients are held in silos and delivered as required, via pipework, to the mixers. Much of the wheat flour used comes in bulk. Under normal operating conditions, employee exposure to dust from bulk ingredients is minimal. However, ingredients which are required in smaller quantities, such as gluten and bread improver, are still handled in bagged form. Employee exposure to dust from bagged ingredients can be significant and comes from ripping open and tipping out the bags, sieving, weighing and adding the ingredients to mixers by hand. These operations are generally separate or distant from other employees in the bakery, thus confining exposure to a fairly well-defined group.

Previous cross-sectional studies have described a varying prevalence of work-related symptoms in bakery employees.^{9–11} In the past it has generally been assumed that all work-related symptoms in bakers have an allergic origin. This assumption is perhaps somewhat surprising as specific IgE to bakery allergens cannot be demonstrated in a large number of cases. In recent years, the question has been raised as to whether alternative mechanisms of non-allergic aetiology may be responsible.^{12,13}

It is perhaps worth considering that the baking industry is somewhat unusual in that employees have simultaneous exposure both to potential sensitisers and

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to relatively high total dust levels. In most other industries, sensitisers are generally encountered against a background of low dust levels. In our experience bakery personnel and other groups who are exposed to dust from grain, flour and other ingredients describe two different patterns of work-related respiratory symptoms, with respect to frequency and persistence.¹¹ One of the patterns consists of a persistent rhinitis or asthma, with noticeable improvement only if away from work for a lengthy period. This would fit the classical model of allergic respiratory disease where there is continuous ongoing exposure to the allergen. Much more commonly, bakery workers describe occasional symptoms which last only a matter of minutes. It is difficult to ascribe such symptoms to allergy, given that both flour and fungal amylase allergen exposures are usually fairly continuous throughout a working shift. Moreover, this group of employees will often point to a particularly dusty task (*e.g.* handling gluten), or exposure to a substance of low allergic potential (*e.g.* icing sugar or baking powder), as the trigger. It is our view that these symptoms are most probably due to a non-specific irritant effect, rather than allergy.

This study describes the prevalence of the two types of symptom profile, *i.e.* allergic and irritant, and also compares the relative potential of bread-making materials, such as wheat flour, soya flour, rice flour and fungal amylase to produce sensitisation in the plant bakery situation.

MATERIALS AND METHOD

The study group consisted of 385 employees from 19 plant bakeries within the UK. The employees chosen were those who were currently exposed, on a regular basis, to dust from bread improver, flour and other ingredients, during their normal work. The tasks which gave rise to the exposure included ripping open and tipping out the contents of bags, sieving ingredients, weighing ingredients and adding ingredients to mixers (dough-making). Employees with occasional exposure to ingredients, such as cleaning or engineering personnel were not included.

Screening consisted of interview and skin prick testing by one of three occupational physicians. Where appropriate, serial peak flow readings were also performed. The interview covered occupational history

in relation to baking and enquiry regarding work-related or allergic respiratory symptoms. In particular, employees were asked about symptoms relating to possible rhinitis, conjunctivitis and asthma.

Skin prick testing was performed against a standard set of solutions, namely: saline and histamine controls; commercially available common environmental allergens, *i.e.* house dust mite, cat fur and mixed grass pollens (Biodiagnostics Limited); work-related allergens at a concentration of 1 mg/ml⁻¹, *i.e.* wheat flour, soya flour, rice flour and *Aspergillus*-derived amylase. The wheat flour used to make up the skin prick test solution was a standard bread-making variety with no fungal amylase added during milling. Skin prick tests were read after 10 minutes and were considered to be positive if there was a weal of at least 3 mm diameter.

Following interview and skin prick testing, employees were allocated to one of four diagnostic categories: occupational asthma; occupational rhinitis; respiratory irritation; or asymptomatic (*i.e.* no work-related symptoms). The principal determinant of allocation to occupational asthma or occupational rhinitis categories was the presence of persistent relevant work-related symptoms. If employees had both asthma and rhinitis, the asthma was considered to be the more important condition and thus the individual was allocated to the occupational asthma category. Where work-related symptoms were intermittent and/or short-lived (*i.e.* resolving within the working shift), a diagnosis of non-specific respiratory irritation was made. For the purpose of this study, atopy was defined by positive skin prick tests to one or more of the common environmental allergens, *i.e.* house dust mite, cat fur or mixed grass pollens.

RESULTS

A total of 383 employees were seen across 19 bakeries, with two employees at one of the bakeries declining to participate. This represents a response rate of 99.5% among the employees who were engaged in regular handling of ingredients at the time of the study. Out of the total, 132 (34%), were atopic.

The division of employees into the four diagnostic categories is shown in Table 1, with a further breakdown of the categories for non-atopic and atopic personnel. The overall prevalence of occupational asthma and occupational rhinitis was low, *i.e.* 0.5%

Table 1. Diagnostic categories

Clinical category	Whole group		Non-atopics		Atopics	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Occupational asthma	2	(0.5%)	1	(0.4%)	1	(0.8%)
Occupational rhinitis	10	(2.6%)	5	(2.0%)	5	(3.8%)
Respiratory irritation	66	(17.2%)	37	(14.7%)	29	(22.0%)
No work-related symptoms	305	(79.7%)	208	(82.9%)	97	(73.4%)

Table 2. Findings from skin prick testing against work-related allergens

Skin prick test	Positive across whole group		Positive non-atopics		Positive atopics	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Wheat flour	24	(6%)	4	(2%)	20	(15%)
Soya flour	24	(6%)	9	(4%)	15	(11%)
Rice flour	14	(4%)	4	(2%)	10	(8%)
Fungal amylase	62	(16%)	22	(9%)	40	(31%)

Table 3. Skin prick test results for different diagnostic categories

Skin prick test	Asthma		Rhinitis		Respiratory irritation		Asymptomatic	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Atopic	2	(100%)	5	(50%)	29	(44%)	97	(32%)
Wheat flour	1	(50%)	3	(30%)	7	(11%)	13	(4%)
Soya flour	1	(50%)	8	(80%)	9	(14%)	6	(2%)
Rice flour	1	(50%)	2	(20%)	4	(6%)	7	(2%)
Fungal amylase	2	(100%)	10	(100%)	18	(27%)	32	(10%)
Total number of individuals	2		10		66		305	

and 2.6% respectively, in comparison with non-specific respiratory irritation, *i.e.* 17.2%. Table 2 gives the numbers and percentages of positive skin prick tests across the whole study group and also for non-atopic and atopic personnel. The prevalence of positive tests to wheat flour and soya flour was similar, *i.e.* 6%, but positivity to fungal amylase was considerably more prevalent, *i.e.* 16%. Atopics had a markedly increased prevalence both of work-related symptoms and positive skin prick tests to work-related allergens. The frequency of work-related symptoms in the atopic group was around one-and-a-half times more common than in non-atopics, while positive skin prick tests for the work-related allergens amongst atopics were at least three times that of non-atopics.

The number and percentage of skin prick test positives for each of the separate diagnostic categories was also calculated. The results are shown in Table 3. The prevalence of positive skin prick tests to both common environmental and work-related allergens was highest in the occupational asthma and rhinitis categories. Although not as marked, the same relationship existed within the respiratory irritation category, in comparison with the asymptomatic group.

The aetiology of symptoms in the group of 12 employees who had either occupational asthma (two) or rhinitis (10), was considered to be sensitisation. In one of the employees with asthma and all 10 with rhinitis, fungal amylase was the suspected sensitiser. The other individual with asthma had symptoms which were attributed to wheat flour sensitisation.

DISCUSSION

The overall prevalence of work-related symptoms from the group of employees in this study (20%) is broadly

similar to that reported from other bakery populations.^{9,10} However, the population in our study is not directly comparable with the others. In the first of these,⁹ the study covered the total production workforce in a single large plant bakery and hence would include some employees with minimal or no dust exposure, *e.g.* those working on the ovens or on slicing and wrapping. The second study,¹⁰ was carried out in a number of small bakeries where the use of bagged ingredients, and hence potential dust exposure, is greater.

In our population the prevalence of persistent work-related symptoms is low (asthma 0.5%, rhinitis 2.6%). This finding suggests that symptomatic allergy to baking ingredients is relatively uncommon in plant bakeries, even in the groups who have regular exposure to dusty materials. The apparent low prevalence of occupational asthma compared with rhinitis may be due to the fact that employees who have developed asthma in the past have been moved away from ingredient work due to the severity of their symptoms, whereas those with rhinitis have been prepared to continue.

Taking the different diagnostic categories, *i.e.* occupational asthma/rhinitis, respiratory irritation and asymptomatic, there is a progressively decreasing stratification with regard to the prevalence of positive skin prick tests to the bakery allergens across the groups (Table 3). A similar effect is also apparent for atopy. With respect to the bakery allergens, the reason for the stratification could be that some of the individuals in the respiratory irritation group have been misdiagnosed and their symptoms actually have an allergic basis. We believe this to be unlikely, as the intermittent and short-lived symptom pattern in this group is difficult to link to continuous potential allergen exposure. It is our view that the preponderance of

atopics in the respiratory irritation group, compared with those with no work-related symptoms, has some significance in understanding the concomitant higher prevalence of IgE to bakery allergens. We suggest that the connection between the increased prevalence of positive skin prick tests to bakery allergens, increased prevalence of atopy and respiratory irritation can be explained by the following argument. Firstly we suspect that atopics are at increased risk of acquiring sensitisation to bakery allergens. In addition, the airway hypersensitivity experienced by atopics tends to make them more prone to an irritant effect from the high peak levels of dust exposure which typically occur with certain bakery processes. Thus we think that the causal link is between atopy and respiratory irritation, rather than the presence of IgE to bakery allergens and respiratory irritation.

The skin prick findings summarized in Table 2 show that the prevalence of positive results to fungal amylase is some two to three times that for the other agents. This suggests that fungal amylase is a more potent sensitizer than the other substances although there could be three other possible explanations for the excess: (1) exposure to fungal amylase is greater than the other agents; (2) sensitisation to fungal amylase can arise from exposure outside the bakery and (3) positive skin prick tests to fungal amylase are due to cross-reaction with another common sensitising agent.

The first explanation is improbable since the concentration of fungal amylase in bread improvers does not normally exceed 0.1%. This compares with wheat flour which is present as a filler and typically makes up to 20%, or soya flour which is present for its lipoxigenase activity, typically 40–50%. Moreover, handling bread improvers generally generates less dust than other ingredients such as flour or gluten, probably due to the presence of soya flour which tends to bind the other constituents in the improver. The second and third explanations are also unlikely. Contact with fungal amylase is unusual outside of the baking or detergent industries. Fungal amylase is added to certain washing powders but exposure to dust from these agents in household use will be negligible. On the question of possible cross-reactivity, it is known that fungal amylase has a different molecular structure¹⁴ and is antigenically distinct¹⁵ from amylase which is present naturally in cereal grains. The results from this study suggest that fungal amylase does not cross-react with the common environmental allergens.

The similarity in numbers of positive skin prick tests to wheat and soya flours is probably a reflection of their approximately equal potential to produce sensitisation, since exposure levels for this population of employees will be broadly comparable for each of these materials. Rice flour exposure is generally lower across the population and this possibly explains the smaller prevalence of positive skin prick tests in comparison with wheat and soya.

We believe that the relative prevalence of positive skin prick tests supports the hypothesis that fungal amylase is the principal sensitising agent in modern plant bakeries. Furthermore, the main risk of sensitisation arises from handling bread improvers rather than flour. This observation has important implications both for regulatory authorities who are interested in setting exposure limits and also for company management with respect to the future targeting of control measures to prevent the development of sensitisation in bakery employees.

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