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Determinants of specific sensitization in flour allergens in workers in bakeries with use of skin prick tests

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Abstract. – Baker's asthma, like other forms of occupational asthma is probably the most serious manifestation of occupational allergy among bakery workers. It is caused by immunologic sensitization and subsequent allergic reactions in the airways to occupational specific airborne allergens. Skin Prick Tests (SPTs) play an important role in the diagnosis of baker's asthma and epidemiological field studies on frequencies of sensitization to flour. This paper presents a review of the available literature on prevalence of flours sensitization in bakery workers. Atopy and level of exposure appears to be a very strong determinant for sensitization to flour allergens. Prevention strategies and standard setting are discussed.

Key Words:

Baker's asthma, Skin prick tests, Wheat flour, Specific sensitization, Atopy.

Introduction

Bernardo Ramazzini reported illness associated with baking as early as 1713, including symptoms of cough, shortness of breath, hoarseness, asthma, and eye problems. The primary work related illness associated with flour exposure continues to be rhinitis, conjunctivitis, baker's asthma and dermatitis. The most serious of these is baker's asthma[1].

Baking and biscuit, pastry and cake making processes all involve flour exposures. In small scale bakeries exposure levels have been found to be highest during mixing and baking stages, but in larger bakeries exposures to flour can occur during receipt and opening of flour containers, mixing and baking operations, regardless of the product[2-5].

Although the diseases process leading to the development of baker's asthma is not entirely understood, most evidence indicates that the primary mechanism is a Gell and Coombs type I immunoglobulin E (IgE) immediate hypersensitivity reaction[6-9]. This reaction generally develops shortly after exposure to the antigen, as evidenced by positive skin tests or serum radioimmunoassay tests. The SPT tests have higher sensitivity and specificity than RAST tests (0.23 and 1.00 v 0.20 and 0.93 respectively)[10].

In many studies (Tables I, II) Authors have tried to reveal the prevalence and the determinants of specific sensitization of bakery allergens in workers in bakeries in different countries. Therefore, in most studies skin prick tests and a panel of known baker allergens, like wheat flour, fungal a-amylase, rye flour, oat flour, rice flour, barley flour, etc. were used. Wheal diameters were recorded 10-20 minutes after the application of the antigen in the forearm of subjects, using in parallel histamine chloride and allergen diluents as positive and negative controls respectively. Based on the distribution of the responses to the positive control, a mean wheal response diameter of at least 2-3 mm was considered a positive. Also in the majority of the studies, atopic status was defined as a positive skin prick test to one or more common allergens (grass pollen, animal dander, house dust mites, etc).

The aim of the present review is to report the prevalence of flour's sensitization in bakery workers, in contrast with control groups, and to investigate the pathogenetic determinant factors as described in different studies. Thus, a systematic review was performed of published manuscripts between 1986 and 2008 using PubMed. The search

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Table I. Specific sensitization with flour allergens in bakery workers with skin prick tests in cross sectional studies.

Ref	Type of Country	Study bakery	Control group	Atopy group	Wheat flour (%)	Fungal α-amylase (%)	Soya flour (%)	Rye flour (%)	Oat flour (%)	Mixed flour (%)	Barley flour (%)	Rice flour (%)	(%)
12	AU	18 Met B	176 (90%) bakers	24 slicers and wrappers	–	15	–		–	–		–	–
19	UK	1 MB	279 (88%) bakery employees	–	40	–	–	–	–	5	–	–	
13	It	105 B+PS	226 (82%) Bakers and pastry makers	119 whit e collar workers	23.9	11.9		–	–	–	21.7	–	
14	Fr	1 In B	44 (84.6%)	164 unexposed controls[a]	–	11			–	–		–	–
20	UK	3MB, 3M, 1 FP	344 (86%)	–	34	–	5			–	4	–	–
23	Fin	4 B, 1 M, 1 CF	153/62/150	–	66/15/25						12/6/8		
24	UK	19 PB	383 (99%)	–	34	6	16	6					4
15	Cro	CI	93 (92%)	65 unexposed[b]							25.8		
16	Germ	B	89+104[c]	43 workers not to bakeries	33/62	16/47	19/24	1/11	11/ 37				
25	UK	3 LB, 3 FM, 1 PS	246	–	35.36		4.68				3.9		
26	Serb	B	100	–	18	15							
27	Ita	2 LB, 3 IM	186+111[d]	–	33.6/30	20/0.2							
17	Bel	70 SB, 4 IB	246	251[e]	29.9	12.4	7.5		3.3				
28	Nor	6 B	197	–	29	4	7		1	1		3	

MB: modern bakery, Met B: metropolitan bakery, B+PS: bakeries and pastry shops, In B: Industrial bakery, (a): electrical engineering, salt–packing factory, food distribution, stationery factory, glass shop and miscellaneous, M: mills, FP: flour packing factory, CF: crisp bread factory, PB: plant bakeries, CI: confectionery industry, (b): control workers in the same industry. (c): 89 workers in bakeries and 104 subjects who filing a claim for compensation of bakers asthma. LB: large bakery, FM: flour mill, PS: packing station. (d): 186 bakers and 111 millers (e): workers from petrochemical plant.

Table II. Specific sensitization with flour allergens in bakery workers with skin prick tests in prospective studies.

References	Country	Study group	Atopy (%)	Wheat flour (%)[a]	α-amylase (%)[a]	Wheat flour (%)[b]	A amylase (%)[b]
29	Italy	125 trainee bakers	–	3.2		10.1	
30	UK	300 Workers[c]	34	4%[d]	5	12	
31	Canada	188 pastry makers	47.5	5.2		9.67	
32	Poland	287 apprentices	18.8	0.7 %		11.2	

a: baseline examination, b: end of study, c: workers in 3 large bakeries, 3 mills and 1 flour packing station, d: mixed flour.

terms that have been used included skin prick tests; sensitization in common allergens, and atopy, in bakers the findings concluded cross-sectional and prospective studies (Tables I, II).

Discussion

Bakery workers usually have sensitization in flour allergens, with the higher prevalence being for wheat flour (4-47%), and for fungal α-amylase (4.68-24%). These results are well predictable since almost all bakeries wheat flour is used for bread manufacturing than α-amylase (as baking additives). The main reason for ranging in prevalence of flour's sensitization is that the methods that have been used varied from study to study, since extracts available for bakery allergens are not standardized, and the origin and concentration of the extracts used for skin prick testing were quite different. However, most of the studies suggested that the prevalence of immunologic sensitization was significant higher in bakers compared to the control groups[11].

Also few data are available on sensitization to wheat flour and α-amylase in populations without occupational exposure to these agents[12-17]. The prevalence range in that population was between 0.4 to 6%. These studies suggest that there is at least some background level of sensitization in the general population, probably due to an increased propensity to develop IgE-mediated sensitization in individuals with immunologic sensitization to several common allergens, or as a result of cross reactivity to other allergens, i.e. pollens[18].

The findings of studies above are that atopy appears to be a very strong determinant for sensitization to flour allergens, with reported Odds Ratios range from 3.7 to 20.8. Some studies showed that the level of exposure is also an important risk factor for the immunologic sensitization. Musk et al[19] showed that the sensitization to wheat flour was more common among the highly exposed workers compared with the low exposed workers (OR: 3.0). Cullinan et al[20] reported that the frequency of sensitization to wheat flour and α-amylase tended to increase with intensity of both dust exposure and wheat allergen exposure. Also Houba et al[21] found a strong and positive association between the wheat flour allergen exposure and the wheat flour specific sensitization. In an Italian study[13] sensitization was significantly associated with cigarette smoking (OR: 2.7), and work seniority (OR: 1.03). Age, sex and gender have not been reported to be determinants of sensitization.

In our study[22], which had performed in south west of Greece, among 58 bakers in traditional bakeries, with use of skin prick tests, we found the prevalence of sensitization in wheat flour was 17.24%, with atopy to be a determinant factor (OR=8.8, 95% CI: 1.44-68.94). Also in this paper the percentage of control group (cleaners) with specific sensitization in bakery allergens was 2.2%. It was also shown that the smokers in the group of bread producers showed a slightly decreased risk of sensitization in wheat flour (OR=0.17, 95% CI: 0.03-1.06), results which are in agreement with Niewenhuijsen et al, where the risk of sensitization was increased (prevalence ratio – PR: 0.7), but no significant[12].

Based in prospective studies, positive skin tests in occupational allergens is a significant factor for development work related respiratory symptoms, but not positive skin tests (atopy) in common allergens.

So the main purpose for the prevention of bakery allergy must be the examination of atopy, the avoidance immunologic sensitization in bakery allergens and the control of intensity exposure in dust flour, which did not examine in that study.

The prevention must be focused in four stages, including the assessing of bakery dust levels and risk, controlling dust levels, wearing protective clothing and equipment and health surveillance for respiratory issues.

The first step is to determine flour dust levels to which workers are exposed, with measurement of airborne dust levels using sampling apparatus and send samples to a suitable laboratory for analysis. When the dust levels are determined, these can be compared with the flour maximum exposure limit (MEL) and short-term exposure limit (STEL) to help determining the risk. The MEL in Greece is 10 mg/m^3 and 5 mg/m^3 for inspirable and respirable fraction respectively.

Dust levels can be controlled either by making changes to plant and equipment (engineering controls) or by changing working practices. So an improvement to local exhaust ventilation is mandatory in order to extract dust of machines and at processes that emit dust. Also a thorough examination and test of the dust extraction equipment should be carried out at least every 1-year.

Making simple changes to working practices can greatly reduce worker's exposure to flour dust. Such practices must use dredgers or sprinklers to spread dusting flour, avoidance of spillages of flour and where spillages are used, cleaning should be immediately, avoidance of the use of compressed airlines for cleaning, avoidance of raising dust when loading ingredients into mixers and starting up mixers on slow speed until wet and dry ingredients are combined. Finally the use of alternative forms of flour treatment improver, for example pastes, liquids and dust-suppressed powders eliminate or reduce the risk of breathing in the dust.

Protective clothing and equipment included respirators, who should only be worn where other control measures are not reasonably practicable or do not provide adequate control. For workers with no facial hair, disposable masks classified as type FFP3 or half masks with P3 filters should provide sufficient protection for most short- term tasks (for the prevention from particles). Powdered respirators with P3 filters should be worn by people with facial hair (including those who are unshaven) and for longer-term tasks.

Health surveillance must be undertaken to enquire positively about the early symptoms of ill health. At least the following arrangements should be in place:

- Pre-employment screening that includes a questionnaire about present or past asthma or chest illness.
- A questionnaire must be completed by all workers at least annually to enquire about any developing symptoms.
- Skin prick tests at the beginning of working as a baker, for the searching of atopy and then at least annual for the searching of immunologic sensitization in flour allergens.

A major part in the prevention of baker's allergy, either respiratory or immunologic is the involvement and cooperation of an occupational hygiene consultant and a specialist of occupational medicine, who will inform the employers for the hazards of their work, train them, and control the conditions of work. However, in Greece the law commits only the companies with more than 50 workers to use specialist in occupational medicine, as a result no one check the conditions of health and safety in traditional bakeries, where the workers are less from 5. So the solution may be the contact of federation of bakers with specialist in occupational medicine for the major of bakers, and no for each bakery separately.

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