

Coffee Worker's Allergy

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Workers in the coffee industry were investigated. Study I comprised 50 selected cases of whom 25 had work-related symptoms and 25 had not. Prick tests and RAST investigations with different factory dust extracts were performed. Study II was a cross-sectional study comprising 129 workers who were prick-tested with one factory dust extract and with castor bean (CB). More than 40% described occupationally related asthma, rhinitis, conjunctivitis or pruritus, and in about half of these cases sensitization with one or two allergens was found. One allergen comes from coffee beans and is found in the factory dust, mainly where the raw coffee is handled. This allergen is destroyed in the roasting process. The other allergen is identical with the allergen from castor bean and is presumed to enter the plant via the sacks. Predisposing factors to developing sensitization were atopic status, degree and length of exposure, and smoking habits.

Key words: atopy; castor bean; coffee bean; coffee industry; exposure; occupational allergy; smoking.

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An occupational allergy in coffee industry workers was first reported by Figley et al. in 1950 (4), who described seven patients suffering from asthmatic symptoms at work. They found that castor bean (CB) was the responsible allergen and assumed that the coffee sacks were contaminated with castor beans before they were used for coffee. In 1957 Bruun (3) demonstrated the role of coffee as an occupational allergen. An extract from coffee beans gave positive skin tests in symptomatic workers, and Prausnitz-Küstner tests were carried out with the same extract. Freedman et al. (5) considered coffee bean sensitivity to be due to chlorogenic acid, which is a low molecular weight component widely present in fruits and plants. Later studies by Layton et al. (9) showed that chlorogenic acid was not identical with the allergen in coffee beans. In 1978 Karr et al. (6) described six symptomatic coffee workers who had positive skin reactions in tests with extracts made from green coffee beans (GCB) and factory dust, and positive RAST to both GCB and CB extracts. In RAST inhibition studies the GCB and CB allergens were found to be different.

Karr et al. (7) estimated the prevalence of work-related symptoms in the coffee industry to be at least 9% (12 symptomatic workers out of 140). Kaye et al. (8) found about 10% (39 out of 400).

In 1977 we were consulted about three patients who worked at two different coffee plants and who had allergic symptoms at work. We made an extract of the factory dust and found IgE antibodies against the dust in the patients' sera. The present study was undertaken to make a closer analysis of this occupational disease, especially concerning the following aspects:

1. Type of symptoms and their prevalence.
2. Occurrence and importance of IgE-mediated sensitization and the relative importance of allergens from coffee beans and castor beans.
3. Factors which might contribute to symptoms, such as atopy, degree of exposure and smoking habits.

MATERIAL AND METHODS

Two studies were carried out. The first was a preliminary one with selected cases from two coffee processing plants (study I). The second, which was undertaken 2 years later, was a cross-sectional study at the larger factory (study II).

The industrial process

The general procedure was roughly the same in the two processing plants (Fig. 1). The raw coffee beans were delivered by railway wagons to the factory in 60-kg burlap sacks. The sacks were opened manually and the beans put into a container, where they were cleaned mechanically from chaff, hulls and stones, etc. A fine flour-like grey-green dust spread into the air in this department. The beans were then transported pneumatically in a closed system to silos. From there the coffee was delivered to roasting machines, then to machines for grinding, packing and dispatching.

The dustiest premises in a roasting plant is where the raw or green coffee beans are handled – the raw coffee department. A fine dust covers the floor, walls and machines. Measurements in such a department showed a total amount of organic particles of a size down to

0.0001 mm of 5.9–6.3 mg/m³ (the threshold limit for organic dust in Sweden is 5.0 mg/m³). Dust was also distributed throughout the rest of the building, but to a much lesser extent.

STUDY I

Patients

The two processing plants had about 170 employees. Twenty-five persons who suffered symptoms at work and 25 without such symptoms were selected. Both groups comprised workers from various parts of the factory with roughly the same amount of exposure to dust.

The group with symptoms comprised 22 men and three women, with ages ranging from 20 to 64 years (mean 34 years). They had worked at the plant for an average of 7.4 years. The asymptomatic group consisted of 20 men and five women, with ages ranging from 19 to 60 years (mean 41 years). Their mean duration of work at the plant was 6.7 years.

Questionnaire

The workers answered a questionnaire which dealt with heredity, previous allergic diseases,

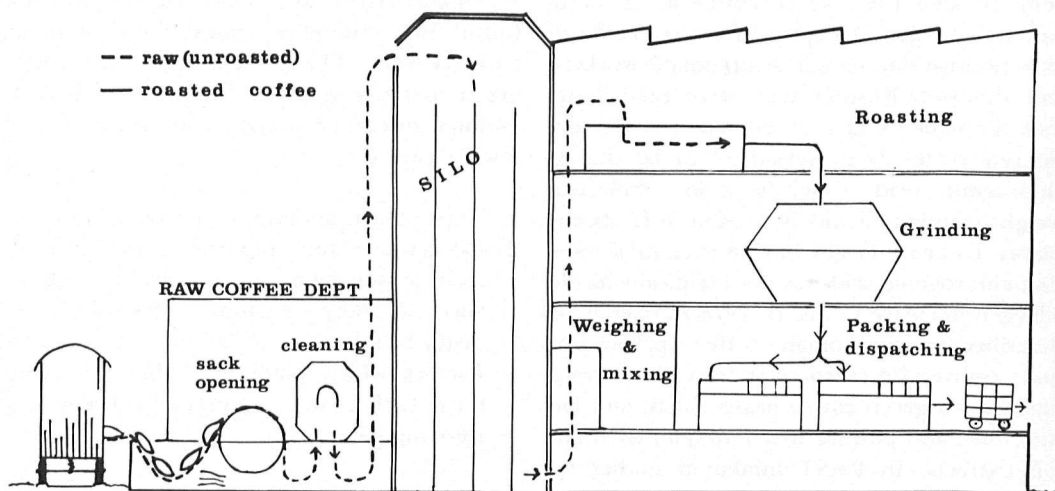


Fig. 1. Schematic representation of a coffee processing plant.

smoking habits, number of years at the plant, in which department they were or had been working, whether they had symptoms related to work, and, if so, of what type.

Allergy tests

Prick tests were performed by one of the authors with a tuberculin needle as described by Pepys (10). After 10 min the reactions were determined by measuring the largest diameter + the perpendicular diameter ($D+d$). A wheal size of 2×2 mm or more was considered positive. A reaction similar to or larger than the wheal obtained with histamine solution (1 mg/ml) was regarded as strongly positive (+++), and intermediate reactions were designated ++ (1).

The following extracts were used: Six various extracts from factory dust (see below), five commercial extracts of common allergen supplied by Dome (house dust, *Dermatophagoides pteronyssinus*, cat, timothy, birch) in a strength of 1:10 (w/v). The workers were also pricked with chlorogenic acid 1 mg/ml, histamine HCl 1 mg/ml, and Coca's solution.

A sample of venous blood was taken and IgE in serum was determined by Phadebas IgE PRIST® (Pharmacia Diagnostics AB, Uppsala) following the directions for use.

IgE antibodies were determined by RAST, using allergen-coated filter paper discs. An immunosorbent purified ^{125} I-labeled anti-IgE with D52 specificity was employed in the tests. Allergen discs were prepared, using the six factory dust extracts, CB, and chlorogenic acid. When a prick test was positive with some of the common allergens, RAST investigation was also made.

The results of the RASTs were grouped in classes according to the concentration of IgE antibodies, measured in PRU (Phadebas RAST Units), using the Phadebas RAST reference.

Antigen preparations

Dust samples were collected from six different places: from the floor of the raw coffee department (Nos. 1 and 2), from the upper part of the

silos (No. 3), from the room where the empty sacks were placed (No. 4), from the floor just in front of the machine where the sacks were opened (No. 5), and from one of the roasting machines (No. 6); this sample consisted of roasted particles of beans and hulls. Sample No. 1 was taken from the smaller processing plant, samples 2–6 from the larger one.

The various samples were extracted in Coca's solution, weight volume 1:10, and used for prick tests and RAST.

STUDY II

Patients

All the workers in the main plant building who had been working there for more than 3 weeks were asked to answer a questionnaire. The investigations were made at their place of work during the three different day shifts. Out of 139 persons, 129 took part in the study. (52 women and 77 men). Their ages ranged from 18 to 62 years, with an average of 36 years. Twenty-five participated in both study I and study II.

Allergy test

Prick tests were made with a partly purified GCB extract, a CB extract and histamine HCl 1 mg/ml.

Antigen preparations

The extract made from GCB, sample No. 1, was chromatographed on a Sephadex G-50® column. The allergenic activity was identified by RAST inhibition and prick tests. Active fractions were pooled and used for RAST and prick tests (to be published).

The CB extract was made from a freeze-dried preparation (a gift from R. Panzani, Marseilles) dissolved in Coca's solution, and was used in prick tests in a strength of 1 µg/ml. Allergen discs were also prepared for RAST testing.

Criterion of sensitization

Since IgE sensitization does not always lead to allergic symptoms, we chose to judge sensitization on the basis of prick tests and RAST. A sensitized worker had a positive RAST for GCB or CB, or a positive prick test reaction to GCB or CB extract.

RESULTS

Type of symptoms

Study I. The 25 workers had the following symptoms: cough, wheezing in the chest, and dyspnoea of various degrees (five), sneezing, itching of the eyes and nose, nasal congestion, lacrimation (nine), breathing symptoms and symptoms from the eyes and nose (nine), itching of the skin together with nasal symptoms (two), and itching alone (two).

Most of the workers reported that their symptoms were aggravated the more dust there was in their surroundings, and all were improved when away from work. Some of them developed more symptoms after a vacation of some weeks than after a weekend. Other workers were more or less free from symptoms on their first working weekday and worse on Fridays and Saturdays. Five of the workers had to take occasional sick leave on account of their symptoms but were not entirely free from symptoms during the work-free periods either.

Study II. Of the 129 workers, 56 had noticed various symptoms related to their work. The most common symptoms were of the allergic type in the nose and eyes (31 workers). Nineteen persons had respiratory symptoms, nine of them had nasal symptoms as well. Twenty-one complained of skin symptoms, chiefly itching with no visible lesions or with small itching red spots, and six cases had eczema. Eleven workers had skin symptoms as their only complaint.

Allergy tests

The five different extracts from raw coffee (extracts 1–5) gave prick test reactions of fairly

similar magnitudes. The extract from the roasting machine (extract No. 6), however, gave markedly smaller reactions. The mean values for the prick tests in the symptomatic and the asymptomatic groups are given in Table 1. Prick tests with chlorogenic acid gave no reactions at all. One symptomatic worker with a negative skin test was excluded as he was on a psychotropic with an anti-histamine effect and had no histamine reaction.

The values obtained at the RAST investigations also varied only slightly between the five raw coffee extracts. Extract No. 6 gave lower values than the unroasted extracts (Table 1).

The results of the RAST investigations are seen in Table 2. No worker without symptoms and with negative prick tests had a positive RAST.

From the findings it was concluded that extract No. 1 was at least as suitable as the other four raw coffee extracts, and No. 1 was therefore used for the antigen preparations in study II, as mentioned above.

A positive RAST for CB was found in 19 workers. This group included the 12 workers with positive RASTs for GCB. The RAST values were generally higher for CB than for GCB (see Table 1).

Eighteen workers with symptoms and positive RAST for coffee or CB had a mean prick test value with GCB extracts 1–5 of 10.6 mm (D+d). Of the six with symptoms but with negative RAST for GCB and CB, only one had positive prick test. This shows a good consistency between RAST and prick tests, especially when CB is included.

Study II. Of the 129 workers, 28 had prick test reactions of 2×2 mm or more with coffee or CB extract. The results are shown in Table 3. The mean size of the test reactions to the coffee extract (D+d) was 6 mm (range 4–12 mm). The reactions to CB extracts were mostly larger, and the mean size was 14.5 mm (range 4–23 mm).

Of the 28 persons with reactions of 2×2 mm or more, 20 had rhinitis, cough or wheezing in the chest at work, one had headache as his only

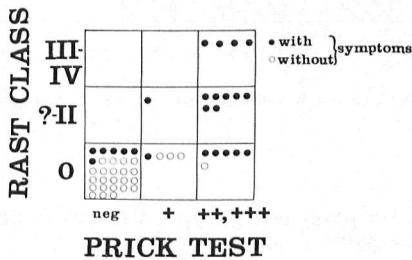
Table 1

RAST-classes for CB and RAST-classes and mean values of prick test reactions (D+d) with different coffee factory dust extracts in study I

Extract	Symptomatic workers						Non-symptomatic workers					
	No. workers in RAST-classes					Mean value of prick tests (D+d) mm <i>n</i> = 24	No. workers in RAST-classes					Mean value of prick tests (D+d) mm <i>n</i> = 24
	0	I	II	III	IV		0	I	II	III	IV	
Castor bean	7	2	1	3	12		24	0	0	1	0	
Factory dust extracts												
1	13	5	3	4	0	8.8	25	0	0	0	0	0.6
2	13	5	3	4	0	7.8	25	0	0	0	0	0.9
3	13	5	3	4	0	9.0	25	0	0	0	0	1.0
4	13	5	3	4	0	8.6	25	0	0	0	0	0.8
5	13	5	3	4	0	6.9	25	0	0	0	0	0.4
6	18	3	3	1	0	3.9	25	0	0	0	0	0.2
Histamine 1 mg/ml						11.2						11.0

Table 2

Correlation between results of prick test and RAST using
GCB extract No. 1 in the workers from study I



symptom at work, and one had itching of the skin. Six denied symptoms.

Factors contributing to sensitization

According to the criterion of sensitization, 22 persons were definitely or possibly sensitized in study I and 28 persons in study II.

Atopy

Study I. Workers with either one positive RAST or at least two positive skin tests to common allergens were classified as atopics. According to this, 12 were atopics: nine (40%) of the 22 sensitized workers and three (10%) of the 28 non-sensitized. The higher proportion of

Table 3

Results of prick tests (D+d) with GCB and CB extract (study II)

	With symptoms		Without symptoms	
	GCB	CB	GCB	CB
Smokers	0	5×8	2×3	0
	0	3×4	3×3	0
	2×2	1×1	2×2	7×7
	2×2	0	2×2	3×3
	2×2	4×6		
	2×2	7×10		
	2×2	5×7		
	2×3	10×12		
	2×3	4×5		
	3×3	8×10		
	3×3	8×14		
	4×4	6×8		
	3×5	2×2		
	3×5	8×14		
	5×5	6×7		
	4×6	6×8		
	3×9	7×14		
	2×2	0		
Non-smokers	0	7×7	0	4×6
	2×2	11×12	2×2	1×1
	3×3	7×8		
	4×5	9×12		
Smokers	neg. prick test 17		31	
Non-smokers	neg. prick test 19		34	

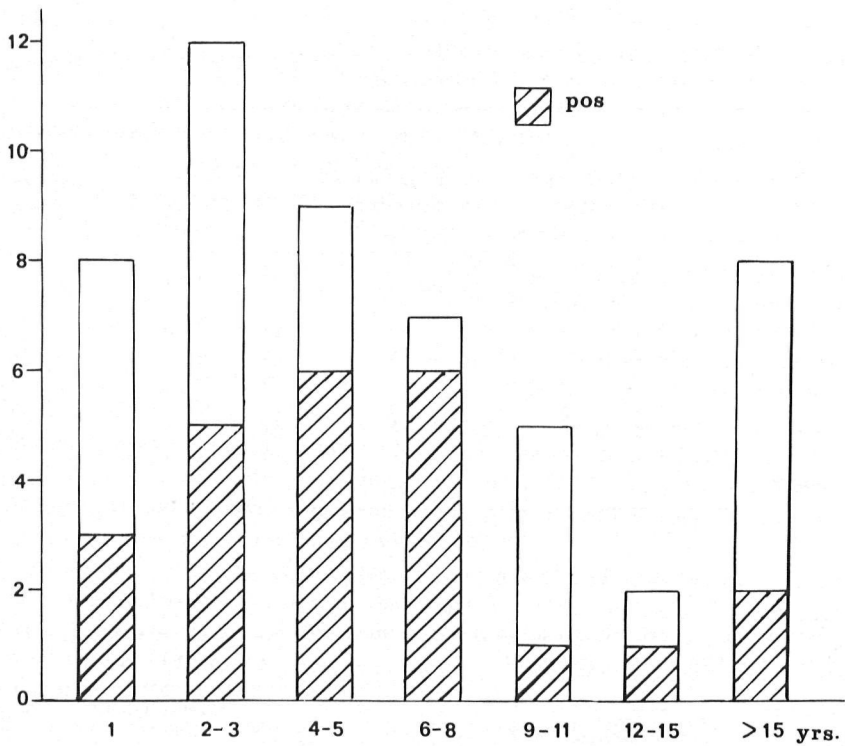


Fig. 2. Number of workers with positive and negative prick tests with GCG or CB and with various lengths of employment (study I).

Table 4

Positive prick tests to GCB and CB in raw coffee workers and others (study II)

	Pos. prick test
All workers <i>n</i> = 129	28 (22%)
Raw coffee workers <i>n</i> = 20	10 (50%)
Others <i>n</i> = 109	18 (17%)

atopics among the sensitized workers was statistically significant ($P < 0.05$).

Study II. In the cross-sectional study the atopy frequency had to be evaluated from the history alone. In the group of 28 subjects with positive prick tests to coffee or CB extracts, nine (32%) gave a history of previous allergies. In the

negative prick test group (101) this figure was 22 (21%).

Degree of exposure

Study I. Twenty-one of the subjects in this study worked in the raw coffee department and 29 in other parts of the plant. Among the raw coffee workers 14 were sensitized to coffee or CB (67%), and among the other workers eight were probably sensitized (27%).

With 22 sensitized persons among the approximately 170 workers at the two plants the sensitization frequency would be at least 13%. If all the workers were separated into "raw coffee workers" (approx. 30) and "others" (approx. 140), the sensitization frequency in the first group would be much higher (47%) and in the second group 6%. These findings support the statement that the risk of sensitization is greater the stronger the exposure.

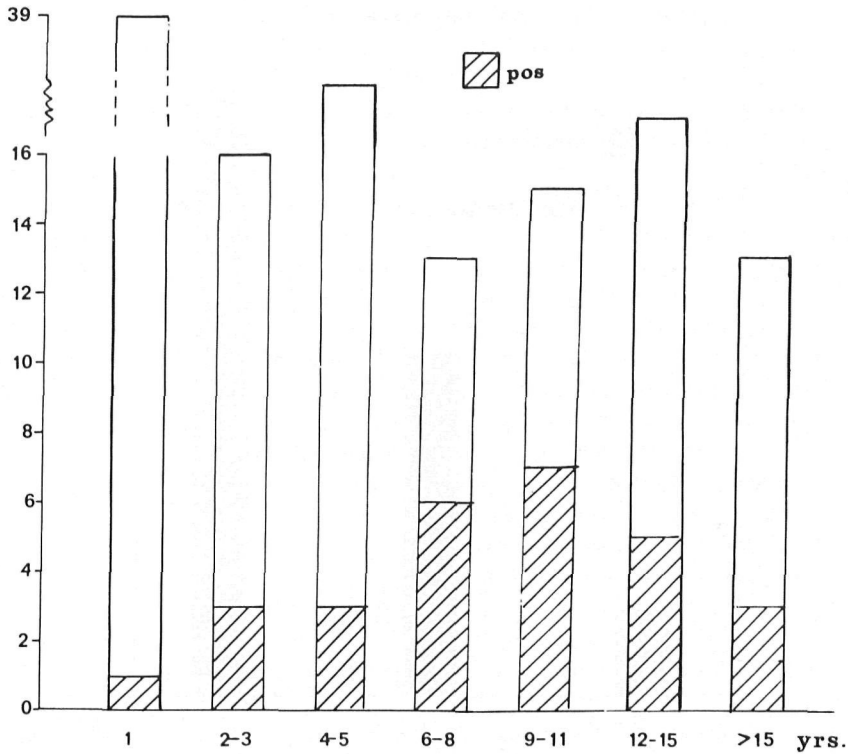


Fig. 3. Number of workers with positive and negative prick tests with GCB or CB with various lengths of employment (study II).

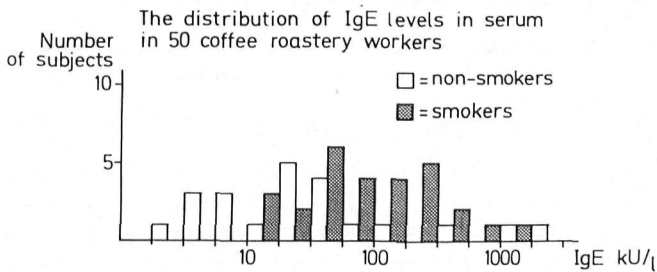


Fig. 4. IgE-values are divided into classes according to a logarithm scale to give a more normal distribution (study I).

Fig. 2 shows the distribution of employees by duration of employment, and proportion of sensitized workers. This proportion rose up to the end of 8 years. The 50 workers had been at the factory for 1 to 25 years (mean 6.8 years). The mean length of employment at the plant was 5.9 years in the sensitized group and 7.6 years in the non-sensitized group.

Study II. Table 4 shows the proportion of positive and negative prick tests among raw coffee workers and others. The sensitization frequency was 22% in the whole group, but as high as 50% among the raw coffee workers.

These 129 subjects had worked at the plant for an average of 6.7 years. In the positive prick test group this figure was 9.1 years and in the negative group 6.0.

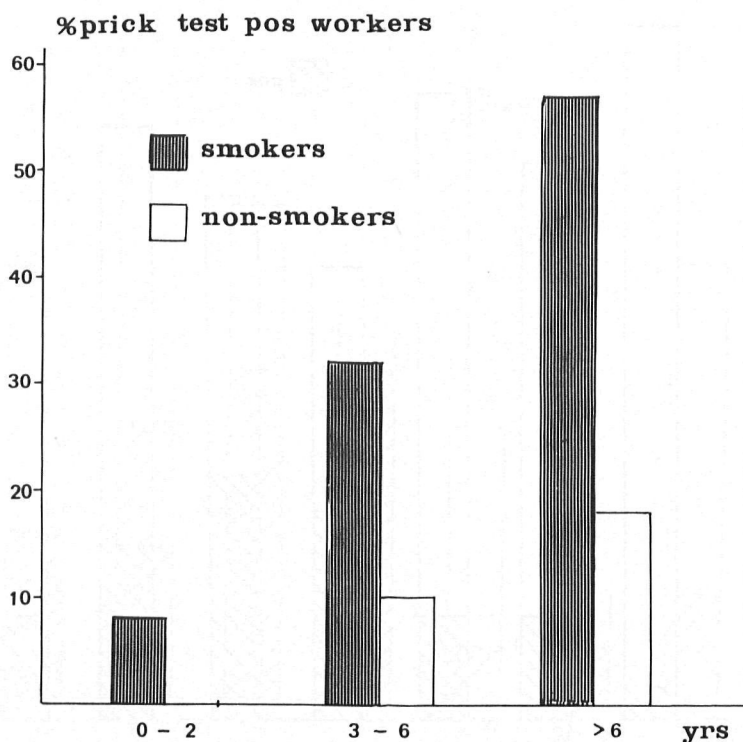


Fig. 5. Positive prick tests to GCB and CB in relation to smoking habits and length of employment. Fisher's exact test in the table is used to test the significance of association between positive prick tests and smoking habits. The significance is greatest for workers with more than 6 years of employment. There is also a significant association between positive prick tests and employment time (smokers 0-2 years and >6 years, P 0.0003*, non-smokers 0.05).

Employment time (years)	Smokers			Non-smokers			Fisher, P
	Pos.	Neg.	% pos.	Pos.	Neg.	% pos.	
0-2	2	23	8	0	21	0	0.29
3-6	7	15	32	1	9	10	0.19
> 6	13	10	57	5	23	18	0.0005*
	22	48	31	6	53	10	0.0003*

Also among these subjects there was a rising sensitization frequency with increasing years of employment up to 6 to 11 years (Fig. 3).

Smoking

Study I. There was a surprisingly large number of smokers among the workers with work-related symptoms, especially those with heavy

symptoms. In the whole group there were 28 persons (56%) who smoked more than one cigarette a day or had stopped smoking the last year. In the sensitized or probably sensitized group there were 16 smokers (70%) and in the non-sensitized group 12 (44%).

Fig. 4 shows the distribution of IgE values in serum among the workers, divided into smokers and non-smokers. The values for the

smokers were distributed at higher levels than those for the non-smokers. The geometric mean value of log IgE for the smokers was 88 and for the non-smokers 30.7 kU/l ($P < 0.05$).

Study II. In this group 54% were smokers. Of the 28 workers with positive prick tests, 22 (79%) were smokers, while of the 101 with negative prick tests 48 (47%) were smokers. This difference was significant ($P < 0.001$).

In this investigation the total frequency of sensitization was 31% among smokers and 10% among non-smokers. The difference in sensitization frequency between smokers and non-smokers was greater the longer the duration of employment (Fig. 5).

DISCUSSION

These studies have demonstrated a prevalence of sensitization among coffee workers of at least 21%. The risk of sensitization is probably greater than is evident from the prevalence figure, since some individuals who developed symptoms at work probably changed to other places of work to avoid further exposure. However, on questioning 13 of the 28 workers who during 1 year had ended their employment at the plant where study II was performed, we found that none had changed their work because of symptoms of an allergic type.

The atopic status of the individual is important. In these two studies we found a higher prevalence of atopy (40 and 32%) among the sensitized than among the non-sensitized (10 and 21% respectively). Since the frequency of atopy in study II was evaluated only from the histories, non-allergic symptoms were also included, which tended to give a higher number of atopics than there were in reality.

There are some factors that are evidently important for the development of hypersensitivity. One is the properties of the allergen. Raw coffee bean dust seems to have an allergen which is moderately potent. High concentrations of dust are needed to evoke sensitization in the great majority of cases. Castor bean, on the contrary, is one of the most potent allergens known, and very small amounts are sufficient

for sensitization. Although castor bean dust is only a contaminant in the coffee industry, we found more persons allergic to castor beans than to coffee. The development of the sensitization seemed to go in parallel. Every worker with a positive RAST for coffee also had a positive RAST for castor bean. A few workers only had a positive RAST for castor bean. However, this would not be explained by contamination of the raw coffee dust extract with castor bean allergen. Raw coffee beans were picked out separately, washed and peeled and used for extract production in order to make a pure raw coffee bean extract. This was used in RAST and correlated well with the raw coffee bean RAST employed (to be published). It is possible that the potent castor bean allergen makes way for sensitization with other allergens, such as coffee. However, no worker reported development of allergy to common allergens after the period of employment at the coffee plant.

The nature and intensity of the exposure also play a role, and it was evident in these studies that these were at least as important as atopy. The persons who worked with the raw coffee had a higher frequency of sensitization than the others – 40 and 50% compared with 4 and 9%, respectively.

Since the number of workers who stopped working in the first year is unknown, it is difficult to draw any conclusions about how the duration of exposure influenced the sensitization. We found most sensitized workers among those who had worked at the coffee plant for 5 to 9 years. In many of these cases it must have taken some years before the sensitization started. This was also consistent with some of the case histories.

A factor which seems to contribute greatly to the risk of sensitization is smoking habits. In the two studies there was a higher proportion of smokers among the sensitized persons (70 and 79%) than among the non-sensitized (44 and 47%). The sensitization also seemed to progress more rapidly. The reason for this is unknown. One theory is that smoking causes damage to the mucosa and thus facilitates penetration of the allergens (13). Mucosal damage is thought to explain the increased

sensitization in patients with cystic fibrosis and anhidrotic congenital dysplasia (11, 12). Thus smoking might have a permissive effect, just as castor bean sensitization might facilitate sensitization to raw coffee bean dust. Since there is no report that atopic diseases are more common among smokers, the effect of smoking might be more evident when there are large amounts of allergen and the exposure time is long, as in occupational allergy.

In the cross-sectional study (study II) there were 36 persons who reported work-related symptoms but had a negative prick test. Eighteen had itching of the skin, sometimes with small red spots and in a few cases slight eczematous lesions. In 14 of them the skin symptoms were their main complaint. Sixteen had nasal symptoms and three had bronchial symptoms as their main complaint. In this group there was no preponderance of smokers over non-smokers (27 *vs* 19) and only one worked in the raw coffee department. There was a predominance of females (23 women, 67%). Some of the symptoms might be caused by unspecific irritation in the airways and skin. The composition of the group and the more uncharacteristic symptoms support the hypothesis that the underlying mechanism is not IgE-mediated. Another possibility is that the persons were sensitized to some other allergen in the plant.

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REFERENCES

1. Aas, K. & Belin, L.: Standardization of diagnostic work in allergy. *Acta Allergol* 27, 439-468, 1972.

2. Bernton, H. S.: On occupational sensitization - A hazard to the coffee industry. *J. Am. Med. Assoc.* 223, 1146-1147, 1973.
3. Bruun, E.: Allergy to coffee. *Acta Allergol.* 11, 150-154, 1957.
4. Figley, K. D. & Rawling, F. F. A.: Castor bean: an industrial hazard as a contaminant of green coffee dust and used burlap bags. *J. Allergy* 21, 545-553, 1950.
5. Freedman, S. O., Krupey, J. & Schon, A. H.: Chlorogenic acid: an allergen in green coffee bean. *Nature* 192, 241-243, 1961.
6. Karr, R. M., Lehrer, S. B., Butcher, B. T. & Salvaggio, J. E.: Coffee worker's asthma: A clinical appraisal using the radioallergosorbent test. *J. Allergy Clin. Immunol.* 62, 143-148, 1978.
7. Karr, R. M., Davies, R. J., Butcher, B. T., Lehrer, S. B., Wilson, M. R., Dharmarajan, V. & Salvaggio, J. E.: Occupational asthma. *J. Allergy Clin. Immunol.* 61, 54-65, 1978.
8. Kaye, M. & Freedman, S. O.: Allergy to raw coffee - an occupational disease. *Can. Med. Assoc. J.* 84, 469-471, 1961.
9. Layton, L. L., Greene, F. C., Panzani, R. & Corse, J. W.: Allergy to green coffee. *J. Allergy* 36, 84-91, 1965.
10. Pepys, J.: Skin tests in diagnosis. In: Gell, P. G. H., Coombs, R. R. A. & Lackman, P. J. (eds.): *Clinical aspects of immunology*, p. 55. Blackwell Scientific Publ. Ltd., Oxford, 1975.
11. Warner, J. O., Norman, A. P. & Soothill, J. F.: Cystic fibrosis heterozygosity in the pathogenesis of allergy. *Lancet* 990-991, 1976.
12. Vanselow, N. A., Yamate, M., Adams, M. S. & Callies, Q.: The increased prevalence of allergic diseases in anhidrotic congenital ectodermal dysplasia. *J. Allergy* 45, 302-309, 1970.
13. Zetterström, O., Osterman, K., Machado, L. & Johansson, S. G. O.: Another smoking hazard: Elevated serum IgE and increased risk of occupational allergy. (Accepted by *Br. Med. J.*).

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