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BYSSINOSIS PREVALENCE AND FLAX PROCESSING*

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Previous evidence suggested that byssinosis in flax workers is caused by the inhalation of dust of biologically retted flax. In the present study no cases of byssinosis were found among workers in a flax plant which produces yarn by chemical degumming instead of biological retting. The absence of byssinosis in this plant could not be attributed to differences in the quantities of dust developed as compared with the conventional retting procedure.

These findings support the view that the agent in flax dust which causes symptoms of byssinosis originates during biological retting of flax and is absent from unretted flax. Chemical degumming of flax appears to be superior to biological retting procedures with respect to the health of the workers.

Ramazzini (1713) first described asthma-like symptoms in flax workers which were caused by the inhalation of dust. This disease, now called byssinosis, is still prevalent among flax workers in several countries (Mair, Smith, Wilson, and Lockhart, 1960; Werner, 1955; Smiley, 1961; Bouhuys, Van Duyn, and Van Lennep, 1961). In one study, a high incidence of byssinosis was found among workers handling retted flax, whereas this disease was absent among workers who handled flax before it was retted (Bouhuys *et al.*, 1961). It was suggested that the dyspnoea-inducing agent in flax dust originated as a metabolic product of bacteria or fungi during flax retting.

Biological retting has many practical disadvantages. It requires much manual labour, its duration is variable and difficult to predict, and weather conditions are important. For these reasons, flax technologists have for many years tried to replace biological retting by chemical degumming methods (Dujardin, 1948), but until recently these chemical methods were apparently unable to compete with biological retting as regards the quality of the yarn.

In recent years, a new chemical degumming method was introduced in The Netherlands and put to extensive trial in an experimental plant. As this labour-saving process proved promising for large-scale industrial application, it appeared important to study whether the new method carries the same health hazard as conventional flax processing methods, and to compare dust conditions in factories using these different methods.

Methods

Flax Processing.—We have described conventional flax processing briefly in an earlier paper (Bouhuys *et al.*, 1961). The new method has been developed in an attempt to mechanize flax processing as much as possible. After deseeding and intensive breaking of the wooden stem, the unretted green flax is passed into a hackling machine which removes most of the wooden parts and short fibres. The flax lint obtained after hackling is made into a coarse yarn. This yarn is degummed and bleached chemically and is then suitable for spinning. Short fibres produced during hackling are treated separately in a similar manner, except for the use of a carding machine to produce a coarse lint from these fibres.

Subjects and Working Conditions.—A detailed history was obtained from all flax workers and technicians employed in an experimental plant using the new process (plant A). This plant has been under development for six years, and the average duration of employment was 18 months. All operations mentioned above were performed in the same room, except for chemical degumming. The

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physiological measurements to be described were made only on workers employed in this room.

The dust produced during breaking, hackling, and short fibre processing was partially removed by an overhead exhaust system providing suction in various locations near the machines.

Dust Sampling Methods.—In plant A, dust was sampled in four locations, *i.e.* at both ends of the breaking machine, near the end of the hackling machine, and near the fibre carding machine. In each location, the total amount of dust, in mg./m³. air, was measured by drawing air at a known constant air flow rate through filter papers which were weighed before and after dust sampling. Four samples were collected on one day throughout the work shift in each location. Collection periods varied from 40 to 100 minutes. In the same locations, dust was collected with thermal precipitators at different times during the same day. The number of small particles and the distribution of particle sizes were determined from the thermal precipitator samples by examining these in a dark field (magnification 500×). The same methods were used to study dust conditions in the conventional flax mill (plant B) for which results of medical investigations have been reported (Bouhuys *et al.*, 1961). Sampling locations in this mill were at both ends of a turbine scutcher, near a hackling machine, and in a flax dressing room.

Physiological Methods.—The volume expired during the first 0·75 second of a forced expiration after a maximal inspiration ($F.E.V._{0.75}$) was measured before and at the end of work on a Monday and Wednesday in 27 workers. In all except one of these workers total white cell and differential white cell counts were made from capillary blood. The methods used for $F.E.V._{0.75}$ and white cell counts were those described in the previous paper.

Results

Incidence of Byssinosis and Other Respiratory Symptoms.—None of the workers in plant A had a typical history of byssinosis (Table 1). Two workers had sometimes been slightly dyspnoeic for a few hours on Mondays, but this had occurred only occasionally. Four others mentioned dyspnoea during work, independent of the day of the week, when they had to do dusty jobs such as cleaning machines. The workers in plant A were appreciably younger than those in plant B, which may account for the lower incidence of chronic cough in plant A. The incidence of asthma, chronic bronchitis, and other allergies among relatives was about the same in both groups, and the workers in plant A did not smoke less than those in plant B. Fifteen workers mentioned nasal obstruction, cough, and dryness of the mouth and throat, which might occur while doing dusty jobs on any day of the week.

TABLE 1

HISTORIES OF FLAX WORKERS IN TWO DIFFERENT PLANTS

	Chemical Retting	Biological Retting
Plant	A	B*
No. of workers	41	24
No. with byssinosis	0	16 (67%)
Age (yr.)	29·8 (18—47)	39·8 (16—68)
Smoking (g./wk)	80·9 (0—240)	70·3 (0—220)
Chronic cough	4 (9·8%)	5 (20·8%)
Asthma *etc.*† among relatives	14 (34·1%)	8 (33·3%)

*Data for plant B refer to workers handling retted flax (Bouhuys *et al.*, 1961).

†Includes histories of other allergies and of chronic bronchitis.

Dust Conditions.—Total amounts of dust (in mg./m³. air) varied but little over the working day (Table 2); lower values occurred when the collection period included a meal break. These have been excluded in calculating average values over the day for each sampling location. In plant A total amounts of dust were higher, and the average number of particles

TABLE 2

DUST CONDITIONS IN TWO FLAX PLANTS

Sampling Location	Total Amount of Dust (mg./m³. air)	No. of Small Particles (< 5 µ) per ml. air		Size Distribution (% by no. of particles)		
		Total	Ash Fraction	< 1·1 µ	1·1 – 4·5 µ	> 4·5 µ
Plant A						
Breaking (1)*	48·8	1,340	1,140 (85·1%)	67·6	25·5	6·9
Breaking (2)*	19·0	1,130	955 (84·5%)	75·5	26·0	3·5
Hackling	7·3	980	780 (79·6%)	78·4	15·8	5·8
Carding	11·4	775	595 (76·8%)	73·8	21·0	5·2
Plant B						
Scutching (1)*	2·0	1,805	735 (40·7%)	—	—	—
Scutching (2)*	0·5	1,695	785 (46·3%)	95·6	3·9	0·5
Hackling	11·3	2,080	900 (43·3%)	—	—	—
Dressing	9·2	2,140	810 (37·8%)	89·5	7·9	2·6

*Sampling locations near breaking and scutching machines were at intake (1) and output (2) of these machines. Values in columns 2 to 4 are means of two to four samples taken at different times during work on the same day in each plant. Columns 5 to 7: measurements made on one thermal precipitator disk for each location.

TABLE 3

CHANGES IN F.E.V.$_{0.75}$ ON MONDAY AND WEDNESDAY IN PLANT A

Work Shift (hr.)	No. of Workers	Monday				Wednesday			
		Before (a)	After (b)	(b)−(a)	Significance	Before (a)	After (b)	(b)−(a)	Significance
6-14	16	3·76	3·77	+0·01	> 0·05	3·54	3·60	+0·06	> 0·05
14-22	11	3·23	2·97	−0·26	< 0·01	3·07	2·94	−0·13	< 0·05

Average F.E.V.$_{0.75}$ (litres B.T.P.S.) before (a) and at the end of (b) work.

TABLE 4

WHITE CELL COUNTS ON MONDAY AND WEDNESDAY IN PLANT A

Work Shift (hr.)	No. of Workers	Monday				Wednesday			
		Before (a)	After (b)	(b)−(a)	Significance	Before (a)	After (b)	(b)−(a)	Significance
6-14	15	10,430	9,690	−740	> 0·05	8,510	8,380	−130	> 0·05
14-22	11	9,830	10,390	+560	> 0·05	9,300	9,310	+ 10	> 0·05

smaller than about 5 μ were lower, than in plant B. There is also a consistent difference in particle size distribution of the dust in the two plants. In plant B about 90% of the small particles is smaller than 1·1 μ; in plant A this percentage is about 75, and the number of particles sized between 1·1 and 4·5 μ is correspondingly larger. In absolute figures, the number of particles of 1·1 to 4·5 μ is larger in plant A than in plant B. Finally, a difference in the composition of the dust is apparent from the larger ash fraction in plant A.

Changes in F.E.V.$_{0.75}$ during Work Days.—The significance of the difference between the F.E.V. values before and at the end of work on a Monday and a Wednesday was tested with Fisher's 't' test for paired variates (Table 3). The workers in the morning shift did not show a significant decrease on either day, whereas the group working during the afternoon and evening had a significantly lower F.E.V. at the end of work on both days.

White Cell Counts.—No significant changes in the total white cell count occurred during the working day in either group of workers (Table 4). Differential white cell counts from blood smears likewise did not show any consistent changes during the day.

Discussion

A high incidence of byssinosis (67%) was found earlier among workers regularly exposed to dust of biologically retted flax in plant B (Bouhuys *et al.*, 1961). In these workers, the F.E.V.$_{0.75}$ decreased significantly during work on Monday but not on Wednesday. Total white cell counts in these workers increased markedly on both Monday and Wednesday. It was suggested that symptoms of byssinosis and a decrease of F.E.V.$_{0.75}$ on Monday were caused by a bronchoconstrictor agent in the dust of dried retted flax. This substance might be a histamine-liberating agent similar to the one demonstrated in cotton dust (Bouhuys and Lindell, 1961; Antweiler, 1960). It was thought that both this and the presumed leucocytosis-inducing agent in the flax dust originated as products of the metabolism of bacteria or fungi during biological retting of the flax. Recently, Nicholls (1962) has shown that flax dust contains a substance which contracts smooth muscle, including human bronchial muscle; this dust, presumably of retted flax, also possessed histamine-liberating activity.

In the present study, no typical cases of byssinosis were found among 41 workers exposed to the dust of chemically retted flax in plant A, and no leucocytosis developed in these workers during the working day. While this appears to support the conclusions mentioned above, some other factors which might explain the absence of byssinosis in plant A should be discussed.

A worker may develop byssinosis within one year after entering an industry where the disease is prevalent, and it is therefore unlikely that the relatively short exposure of the workers in plant A can explain the absence of any disease in a relatively large group of workers. Also important is the fact that eight workers had experienced symptoms of byssinosis while working in plants processing retted flax or cotton before their present employment. They had never had similar symptoms during their work in plant A, although they felt that the new process used in plant A produced at least as much dust as conventional flax processing.

This impression was to some extent confirmed by the results of dust sampling. Total amounts of dust

TABLE 5

F.E.V.$_{0\cdot75}$ CHANGES ON MONDAY AND WEDNESDAY

Work Shift	No. of Workers	Monday	Wednesday	$\bar{d}$	t	P
Plant A						
6-14	16	+0·01	+0·06	0·05	0·68	> 0·50
14-23	11	−0·26	−0·13	0·13	1·69	> 0·10
Plant B						
Byssinosis cases	13	−0·16	+0·03	0·19	4·22	< 0·01
*Plant C**						
Byssinosis cases	17	−0·34	−0·04	0·31	4·84	< 0·01

$\bar{d}$ = difference between mean F.E.V.$_{0\cdot75}$ changes on Monday and Wednesday; t = Fisher's 't' for paired variates; P = probability that t value is caused by chance. *Plant C is a cotton weaving mill (Bouhuys, 1963).

were higher in plant A than in the conventional flax plant B at all except one of four sampling locations. The number of small particles as estimated from thermal precipitator counts was less, but the percentage of particles most likely to be deposited in the lower airways (1·1 to 4·5 μ) was higher in plant A. The higher ash fraction of the dust in plant A is probably related to the fact that plant A processes dry flax straw whereas in plant B much of the adhering sand from the field is removed during retting and drying prior to scutching.

The divergent results of the F.E.V. test in the workers on the two shifts (Table 3) is difficult to explain. The fall in F.E.V. in the workers on the late shift occurred on Mondays as well as on Wednesdays. Table 5 shows that this finding is unlike the F.E.V. changes in byssinosis. In two groups of textile workers with byssinosis (plant B and C, a cotton weaving mill) the F.E.V. change is significantly greater on Monday than on Wednesday. On both shifts in plant A the difference was not significant. Although dust sampling did not show marked variations in dust conditions during the day, the last sampling period (3·50 to 4·30 p.m.) gave slightly higher total amounts of dust at three locations than dust collected earlier in the day. It seems possible that in the late shift workers the fall in F.E.V. was caused by a non-specific irritating effect of the dust. This might also explain why some workers complained of dyspnoea occasionally when they performed very dusty jobs.

The absence of byssinosis among the workers suggests that the chemical degumming procedure developed in plant A offers a definite advance in hygiene. It is, however, still too early to exclude a harmful effect of this type of flax dust on the lungs after long-term exposure, as the new procedure has only been in use for a few years. The non-specific symptoms of nasal obstruction, cough and dyspnoea during dusty jobs, which several workers mentioned, show that adequate dust removal measures should be taken in plants using chemical degumming methods as well as in conventional flax mills.

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