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ORIGINAL ARTICLE

Evaluation of work conditions in a pasta manufacturing plant with particular consideration of dustiness

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Abstract

Objective. The objective of the study was evaluation of work conditions in a pasta manufacturing plant, including: physical and psychological load and factors of material work environment. The main aim was determination of the level of employees' exposure to flour dust.

Methods. Studies of work conditions were conducted in a flour processing plant in the Lublin region at the workplace of an automatic production line – operator of the noodle production line, employees packaging pasta, and the manual line – employees responsible for the kneading of dough, cutter operators, and employees engaged in packaging. Energy expenditure, static load and monotony of the movements performed were assessed as a part of the physical load. Mental effort and monotony of work were assessed as a part of psychological load. Measurements of dustiness, noise, microclimate and lighting were performed according to the Polish standards and regulations in effect. Dust concentrations at work were carried out in the respiratory zone of workers while performing work activities at individual workplaces. Measurements of weight concentrations were carried out in series for individual workplaces, and covered the measurements of concentrations of individual fractions of dust deposited in the sections of the airways (inhaled, thoracic and alveolar).

Results. The evaluation of work conditions, which covered physical and psychological load and factors of the material occupational environment, showed that their values did not exceed the allowable values contained in respective standards. While kneading dough on the manual line, the highest concentrations of dust were observed of inhaled, thoracic and respirable fractions (12.96 mg/m^3; 3.09 mg/m^3; and 0.18 mg/m^3, respectively), whereas the lowest – at the workplace of an operator of an automatic packer (0.39 mg/m^3; 0.14 mg/m^3; and 0.03 mg/m^3). At the workplace of an automatic packer the MAC values for inhaled dust were exceeded. At the remaining workplaces on the manual line, and all workplaces on the automatic line, the MAC values for inhaled and respirable dust were not exceeded.

Key words

evaluation of work conditions, dustiness, flour dust, food processing plant

INTRODUCTION

The food processing industry is a buoyant sector of industry, which covers many specialist branches and enterprises. In the course of time and rapid development of technology, production processes and method of work in this industry have changed considerably. Automation of production processes began to be increasingly widely applied by the introduction of new technologies and new methods of work organization. Technology, while taking care of the final product effectively relieves humans of work, simplifying work processes; however, it also brings about various threats.

Modern appliances become less 'mechanical' but increasingly more 'intelligent' objects which cooperate with the operator and perform many tasks. This determines the aspect of interaction in the human-machine system, where an individual must be prepared for solving problem situations [1].

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In the food industry there occur many unfavourable phenomena and their effects allow the distinguishing of two principal problem groups. The first, and most important problem which requires urgent interventions, concerns occupational disorders. The risk of occupational diseases is reflected by statistical data concerning occupational diseases and accidents. For example, this risk in the food sector in Finland still remains the highest, compared to other branches of industry [2].

Hag [3], based on statistical data, indicates that the Swedish food industry is characterized by a considerably high occurrence of musculoskeletal disorders (MSDs) among employees. In the 1980s in the United States, attention was paid to the common occurrence of musculoskeletal disorders among employees of poultry processing plants, in association with the occupation performed. These disorders covered damage to the nerves, tendons, bones of the hands, neck and spine [4, 5]. According to Young et al. [6], more than a half of workers employed in the poultry industry perform their occupation in conditions inducing MSDs. Among other occupational diseases, MSDs are the main target of ergonomic and medical studies in the food industry [5, 7, 8].

Many work activities performed at workplaces in the food industry are related with the necessity for contact with frozen products, performing work in conditions of considerably decreased temperature, high humidity, high level of noise, dustiness and artificial lighting [9, 10, 11]. The personal features of an individual, such as gender, age, health status, anatomical and psychological traits, as well as life style, may exert an effect on the perception of hazards [9, 11, 12, 13, 14, 15]. The most noxious environmental factors are: noise, lack of ventilation, cold, heat, dust, inadequate lighting, odour, high humidity and vibration [12]. Various combinations of these factors, according to the work activities performed, lead to mechanical and psychological consequences, manifested as occupational diseases [16].

According to the State Sanitary Inspection, in recent years in Poland, the number of employees engaged in the production of food products and beverages who perform work in hazardous conditions has ranged within 105.7 – 109.5 per 1,000 employees [17]. During 3-year supervisions carried out by the State Sanitary Inspection in the food industry enterprises of various production profiles it was found that the employers did not respect their duty to care for work conditions and perform the evaluation of occupational risk. In 67% of plants processing fruit and vegetables, in 77% processing milk and in 65% of enterprises processing cereals, no such assessment have ever been carried out.

In relevant literature, the major studies in the food industry focus primarily on the evaluation of occupational risk and analysis of accident rates. Considering the special character of the work, the occurrence of occupational diseases and provision of work safety, investigations should also focus on constant supervision (monitoring) of factors of the material work environment.

Dustiness is among the hazardous and noxious factors in the work environment in food industry plants. The examples of such noxiousness are found in mills, bakeries, and pasta producing plants, where flour dust occurs [18, 19, 20, 21]. Typical flour dust consists of the grains of starch and cereal proteins; however, it may also contain many non-cereal components, e.g. enzymes, antioxidants, spices, yeast, or powdered eggs, etc. An exposure to flour dust, due to its irritating and allergizing effect, may cause many respiratory diseases, such as: asthma, chronic bronchitis, rhinitis, conjunctivitis, and dermatitis [19, 22, 23, 24, 25].

OBJECTIVE

The objective of the study was evaluation of work conditions in a pasta manufacturing plant, including the following:
- evaluation of physical and psychological load;
- evaluation of the factors of material work environment: noise, microclimate, lighting;
- carrying out studies of dustiness at workplaces in a pasta producing plant.

The main aim was determination of the level of employees' exposure to flour dust while performing the occupation.

MATERIAL AND METHODS

Studies of work conditions were carried out in a flour processing plant in the Lublin region. The main product of the enterprise is pasta, manufactured in 29 varieties. The products are manufactured from raw materials from ecologically pure areas of the Lublin region.

In the enterprise there is an automatic line for pasta manufacturing (kneading of dough, cutting, drying). Packaging pasta into bags is performed by a weighing packaging machine, supervised by employees installing sacks and placing the packed pasta on pallets.

In addition, in the enterprise there is a manual line, where flour and eggs for kneading dough are manually added. The cutting of pasta is operated by employees who receive the cut pasta from the cutter, and place it on pallets in order to put them in dryers. The packaging of pasta is manual, the employees dump dried pasta from the pallets into containers, and from the containers to bags, weigh and seal them, then convey the bags to be placed on pallets.

Work in the enterprise is undertaken in 2 shifts, with a statutory break for a meal. The study was performed during the first shift from 06.00 – 14.00, at the workplaces examined where 11 workers, including 2 women, were employed.

Studies of work conditions included the evaluation of physical load, psychological load, and factors of material work environment.

While evaluating the physical load at workplaces, energy expenditure and physical static load were considered, as well as assessment of the monotype of the movements performed.

Lehmann's method was used for assessing energy expenditure of employees at workplaces in the production of pasta. This method is based on a careful analysis of the working process, considering body positions assumed at work and the degree of involvement of individual muscle groups.

Physical load of a static character was evaluated by the estimation method. For this purpose, work activities performed by employees at their workplaces were observed. The body position of the employees in which they perform their work activities, and in which they remain the longest was a basis for evaluation.

However, when assessing the monotony of working movements the following was taken into account: the number of monotonous repetitions, degree of motor limitations imposed by the physical operation performed, and the amount muscle force developed while performing the movements [26, 27].

Evaluation of mental workload was based on assessment of the mental effort and monotony of work. Mental effort covers the division of labour into three stages: obtaining information, decision-making and execution of activities. The monotony of the working processes is characterized by invariability of the surrounding conditions, the need to pay constant attention and easiness of work [27].

Studies of factors of the material work environment covered measurements of noise, microclimate, lighting and dustiness. The noise measurement was performed with use P01 'Senopan', the microclimate with use of MM01 and EFT2040 'Elbro', and lighting with use of ELX2111 'Elbro'. The measurements were performed according to Polish standards and regulations in effect [28, 29, 30].

Dustiness at work was measured in accordance with the requirements of the Polish Standard PN-EN 481:1998 [31]. The measurements were carried out in the respiratory zone of workers while performing work activities at specified workplaces with the use of a meter GRIMM 1.108, adjusted for performing dosimetric measurements. Measurements of weight concentrations were carried out in series for individual workplaces, and covered the measurements of concentrations of individual fractions of dust deposited in the sections of the airways (inhaled, thoracic and alveolar). Dustiness was measured at workplaces typical of the enterprise where there occurs a potential exposure to flour dust. Dosimetric measurements of dust concentrations were performed at the following workplaces:

- operator of automatic line manufacturing pasta;
- employees of the automatic line engaged in pasta packaging;
- employees responsible for kneading dough on the manual line;
- employees operating cutters on the manual line;
- packers on the manual line.

RESULTS

Final evaluation of physical load for individual workers on the automatic line remained on a low or mediocre level, while this load on the manual pasta manufacturing line was on a mediocre level, due to energy expenditure (3,600 kJ/8h) and static load associated with body position assumed during the performance of work activities.

Evaluation of psychological load showed that at workplaces on the automatic line this load remained on a mediocre or high level. These values are due primarily to the monotony of work, with significant effort associated with the collecting of information and the need to pay constant attention. The psychological load on the manual pasta manufacturing line was on a low level (Tab. 1).

Table 1. Results of measurements of factors of material work environment

Workplace		Microclimate			Lighting lx	Equivalent noise dB(A)
		Temperature °C	Air humidity %	Air flow m/s		
Automatic line	1. Line operator	22.5	48.9	0.18	550	60.2
	2. Press operator	24	49.9	0.17	300	88
	3. Packer operator	23	48.2	0.17	500	62
Manual line	1. Kneading of dough	23.5	50.2	0.15	460	70
	2. Cutter operator	23.7	49.9	0.16	500	68.7
	3. Packaging	22.9	50.1	0.16	520	64.2

The air temperature at workplaces examined, evaluated both on the automatic and manual lines, was from 22.5°C-24°C, and remained within the allowable range for the technological process and did not exert a negative effect on the employees' well-being. Humidity, with an air flow from 0.15 m/s – 0.18 m/s, which did not exceed the allowable value of 0.2 m/s, ranged from 48.2%-50.2%, which evidenced that the optimum microclimatic conditions were maintained.

The intensity of lighting remained with the range from 300-550 lx and was consistent with the standard.

The level of equivalent noise referred to an 8-hour workday was within 60.2-88 dB(A). The allowable value of 85 dB(A) was exceeded at the workplace of a press operator; however, this noise does not require correction because the employee does not remain in this room continuously for 8 hours.

The character of production indicated that there was a necessity to conduct detailed studies of dustiness. Therefore, studies were carried out which showed that the mean concentration of respirable dust in an operator of the automatic line was 0.57 mg/m^3 for inhaled fraction (Tab. 2). For the automatic packer operators the concentrations of inhaled dust were 0.39 mg/m^3, on average, and for employees operating the manual line these concentrations were: at operating the cutter and placing the dough on pallets – 0.71 mg/m^3, on average, and while packaging – 0.76 mg/m^3, while the highest values were noted during the kneading of dough (12.96 mg/m^3). The highest concentration of respirable dust was observed in an operator kneading dough on the manual line – 0.18 mg/m^3, whereas the lowest – while operating the automatic packer (0.030 mg/m^3), and during manual packaging (0.034 mg/m^3).

The highest mean dust concentration for thoracic fraction was noted during the kneading of dough on the manual line – 3.09 mg/m^3, while the lowest – while operating the automatic packer – 0.14 mg/m^3.

Among the workplaces examined, the highest concentrations of the three fractions measured: inhaled, thoracic and respirable, were observed while kneading dough on the manual line, whereas the lowest – at the workplace of automatic packer operator.

Table 2. Selected characteristics of the distribution of dust concentrations at workplaces [mg/m^3].

Type of production line	Workplace	mean	median	variance	standard deviation
		inhaled fraction			
Automatic	line operator	0.5672	0.2534	0.5451	0.7383
	packer operator	0.3923	0.3907	0.0196	0.1399
Manual	kneading of dough	12.9621	5.1358	201.0281	14.1784
	cutter operator	0.7068	0.6774	0.0468	0.2162
	Packaging	0.7596	0.7004	0.0906	0.3011
		thoracic fraction			
automatic	line operator	0.2354	0.1285	0.0709	0.2663
	packer operator	0.1400	0.1316	0.0013	0.0358
manual	kneading of dough	3.0917	1.8243	7.8967	2.8101
	cutter operator	0.2803	0.2653	0.0058	0.0760
	Packaging	0.2010	0.1901	0.0044	0.0662
		respirable fraction			
automatic	line operator	0.0420	0.0344	0.0005	0.0220
	packer operator	0.0296	0.0286	0.00004	0.0061
manual	kneading of dough	0.1837	0.1353	0.0165	0.1285
	cutter operator	0.0666	0.0579	0.0005	0.0214
	Packaging	0.0341	0.0337	0.0001	0.0076

In order to compare dust concentrations at the workplaces examined, the non-parametric Kruskal-Wallis test was used (Tab. 3), due to the lack of satisfaction of the assumptions of the analysis of variance (normality of distribution and homogeneity of variance) required with the classic analysis of variance based on F test. The differences in concentrations between workplaces for inhaled thoracic and respirable fractions are highly significant statistically (Tab. 3).

Table 3. Results of Kruskal-Wallis test for comparison of dust concentrations at five workplaces

	test statistics	p-value
inhaled fraction	52.450	E-10
thoracic fraction	52.018	1.4 E-10
respirable fraction	55.315	2.8 E-10

The concentrations of dust at the workplace 'kneading of dough' considerably differed from other workplaces (Tab. 2); therefore the remaining four workplaces were compared, excluding the workplace 'kneading of dough'. Results of Kruskal-Wallis test (Tab. 4) indicate that after excluding this workplace, significant differences were still observed between the remaining workplaces.

Table 4. Results of Kruskal-Wallis test for comparison of dust concentrations at four workplaces after excluding the workplace 'kneading of dough'.

	test statistics	p-value
inhaled fraction	25.562	1.2 E-05
thoracic fraction	24.895	1.6 E-05
respirable fraction	32.822	3.5 E-07

In addition, concentrations of individual fractions of dust were compared at the workplace of automatic packer operator and manual packer operator. (Figs 1, 2, and 3).

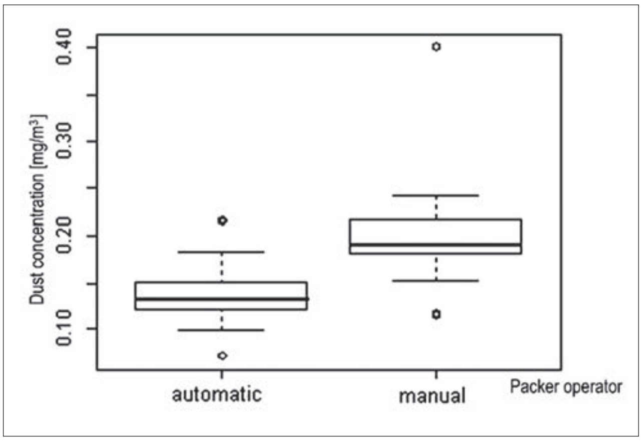

Figure 1. Box-plots for inhaled fraction

In Figures 1,2 and 3, Bold lines inside boxes denote medians, horizontal edges of boxes show the first and third quartiles, whiskers extend to the most extreme data point after excluding the outliers. These outliers are plotted as circles.

Dust concentrations at these workplaces were compared by means of the non-parametric Mann-Whitney test, which showed that for all dust fractions the concentration of dust was significantly lower among operators of the automatic packer.

Inhaled dust and potentially deposited in individual sections of the airways is represented by dust deposited in the head region (non-thoracic), thoracic, and thoraco-bronchial fractions, as dust deposited in the airways covered by ciliated epithelium, which is removed by the cilia of the respiratory epithelium and by the respirable fraction (alveolar), i.e. dust penetrating into the airways not covered with ciliated epithelium is deposited there.

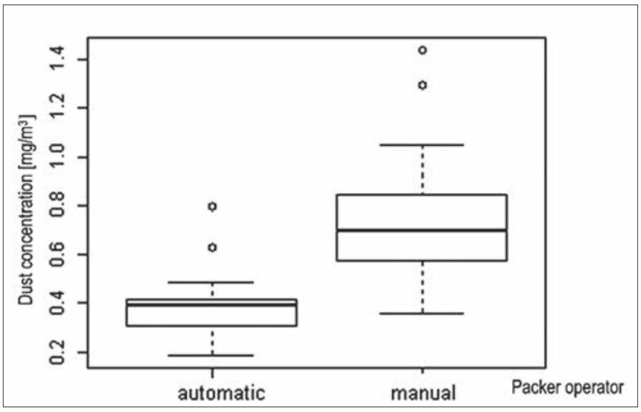

Figure 2. Box-plots for thoracic fraction

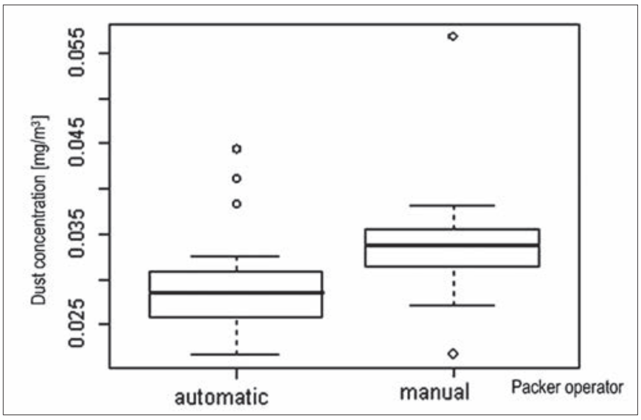

Figure 3. Box-plots for respirable fraction

Based on the results of measurements of inhaled, thoracic and respirable fractions (Tab. 1), the concentrations of indirect dust fractions were determined for non-thoracic and thoraco-bronchial fractions, and the average percentage of individual fractions in the inhaled dust calculated (Fig. 4).

At all workplaces a higher percentage of non-thoracic fraction in inhaled dust was found, with the lowest percentage of respirable fraction. The highest percentage of non-thoracic fraction (deposited in the head region) was noted at the workplace of a packer on the manual line (71.9%), and the kneader of dough (69.7%), with the lowest percentage of respirable fraction (4.9% and 2.4%, respectively). The highest concentrations of thoracic, thoraco-bronchial and respirable fractions in inhaled dust were observed at the workplace of operator of the automatic line (47.4%; 35.7%; 11.7%), with the lowest percentage of non-thoracic fraction, compared to all other workplaces.

The non-parametric Kruskal-Walis test (p-value 1.13 E-07) showed significant differences in the distribution of non-thoracic and thoracic fractions inhaled at various workplaces.

In order to determine which pairs from among the four workplaces (after excluding the workplace 'automatic line operator', characterized by a considerably higher variance) differ significantly, Tukey test was performed, which showed at the level of significance 0.05, that the workplaces may be divided into two separate groups: Group 1 – workplaces 'manual packaging' and 'kneading of dough manual line', and Group 2 – 'operation of cutters' and 'operation of automatic packer'. The percentage of thoracic and non-thoracic inhaled fractions did not differ within the groups. Significant differences were observed between the groups: in Group

1, the percentage of non-thoracic fraction was higher than in Group 2, whereas in Group 2 the percentage of thoracic fraction inhaled was higher, compared to Group 1.

In addition, the non-parametric Mann-Whitney test was performed in order to determine the differences between the workplaces: 'operator of automatic line', and the workplace with the 'closest' distribution, i.e. 'operator of cutters'. The difference in distributions of the percentages of thoracic fraction inhaled was statistically insignificant on the level of 0.05 (p-value 0.091).

In order to determine the percentage of thoraco-bronchial fraction inhaled, the classic analysis of variance was performed, based on the F test (its assumptions were not disturbed), the results of which indicated significant differences between workplaces.

The Duncan test was applied to compare pairs of workplaces (Tukey test did not provide separate groups). The highest percentage of thoraco-bronchial fraction inhaled occurred at the workplace of an 'operator of automatic line', whereas the lowest percentage for the workplace 'manual packaging'. The remaining workplaces did significantly differ on the level of 0.05.

The non-parametric Kruskal-Wallis test (p-value 3.77 E-11) indicated significant differences in the distribution of the percentage of respirable fraction in inhaled air between workplaces. After excluding from the analysis the workplace 'operator of automatic line', variances for the workplaces were the same (p-value for Bartlett's test 0.149), which enabled performance of the classic analysis of variance. Results of this analysis showed significant differences between workplaces. Tukey's test showed on the level of significance 0.05, that only the difference between the workplaces 'automatic packaging' and 'operation of cutters' was insignificant. For these two workplaces the percentage of respirable fraction in inhaled air was the highest, while for the workplace 'kneading of dough' the lowest. Mann-Whitney test for the difference between distributions at the workplace 'operator of automatic line', and the 'closet' distribution – 'operator of cutters' showed that the difference was insignificant on the level 0.05 (p-value 0.129).

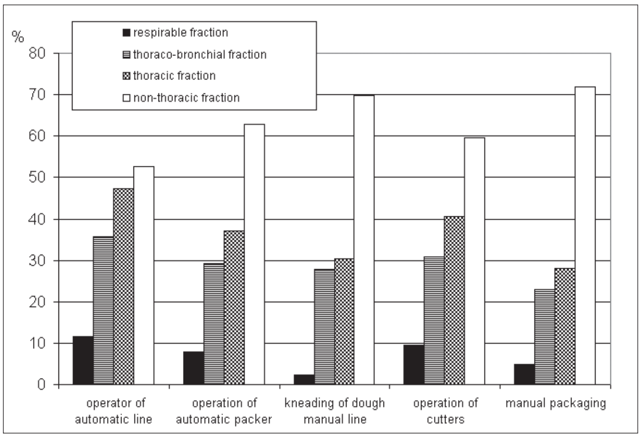

Figure 4. Mean inhaled dust fraction percentage composition for individual workplaces in the pasta manufacturing plant

Hygienic evaluation of occupational exposure to dust. The hygienic evaluation of work conditions involves the MAC values for dust of plant and animal origin. The highest allowable concentration for total dust is 4.0 mg/m^3, while for respirable dust – 2.0 mg/m^3 for dust containing crystalline silica of below 10%. Studies conducted at the Institute of Rural Health in Lublin show that flour dust produced while packaging of flour possesses an admixture of this component in the amount of a maximum up to 2%.

Table 5 presents the estimated level of mean weighted dust concentration in the pasta manufacturing plant. In the case of employees on the automatic line, the MAC values were not exceeded at work, neither for inhaled nor respirable fractions. The MAC values for respirable dust at workplaces of manual manufacturing of pasta were not exceeded. However, in one case, at the workplace on the manual pasta manufacturing line 'kneading of dough', the MAC value was exceeded for inhaled dust (5.40 mg/m^3 with MAC = 4.0 mg/m^3). This probably resulted from the manual conveying of flour, which is confirmed by a high percentage of the non-thoracic fraction. It is necessary to repeat the studies of dustiness for this workplace, and to undertake actions aimed at the reduction of dustiness during the manual manufacturing of pasta.

Table 5. Values of mean weighted concentrations of inhaled and respirable fractions of dust for the work shift of employees of a pasta manufacturing plant [mg/m^3]

	Workplace	Mean weighted dust concentration	
		Inhaled fraction	Respirable fraction
Automatic line	Line operator	0.28	0.02
	Packer operator	0.29	0.02
Manual line	Kneading of dough	5.40	0.08
	Cutter operator	0.35	0.03
	Packaging	0.57	0.03

DISCUSSION

The studies of work conditions, which covered physical load, psychological load and factors of material work environment, indicated that these conditions provided work comfort, because the values did not exceed allowable values contained in the relevant standards (Tab.1).

A review of relevant literature showed that the evaluation of the factors of the work environment has been carried out in a similar pasta manufacturing plant in Italy. The measurements performed were limited to the measurement of noise and dustiness [32]. The level of equivalent noise was on the threshold or above the standard in effect in Italy (87 dB(A)) and was from 86.1 dB(A) – 94.1 dB(A). In the studies conducted by Bianchi, the measurement of noise, compared to the measurements conducted by other researchers, were also carried out within a time shorter than 8 hours (2 hours and 47 minutes, respectively) and showed that the level of noise was lower than for measurement during 8 hours. Despite the shortened time of performing the measurements, the level of noise was higher than that determined in the presented study.

In other studies conducted by Pawlak [33], the equivalent noise was similar and exceeded the Polish standard – from 80 dB(A) at the workplace of a control room operator, to 90 dB(A) at the workplace of press operator.

Results of studies of the fraction flour dust concentrations allowed the recognition and assessment of exposure to dust deposited in individual parts of the airways at the workplaces of employees of the pasta manufacturing plant in the Lublin region (Tabs. 2, 4).

The results of studies of exposure to flour dust available in literature concern primarily bakeries engaged in baking bread, rolls, and various types of confectionary. These are traditional bakeries, as well as industrial bakeries and in supermarkets [20, 34]. In addition, the studies most frequently covered the measurements of inhaled dust or PM_{10}.

In British bakeries, an individual exposure of an employee to total dust was from 0.4 -6.4 mg/m^3 [21]. In French bakeries, the mean dust concentrations were 4.9 mg/m^3 [35], and according to Bohdan [36], the mean level of dustiness in an industrial bakery was <10 mg/m^3, and reached 41.3 mg/m^3 only in the special packaging zone

The results of studies conducted in various countries indicate that higher dust concentrations are noted during the mixing of ingredients (flour, eggs, admixtures) in bakeries [18, 19, 21, 37], and during the packaging of pasta [32] in pasta manufacturing plants. In 6 Finnish bakeries the concentration of dust during weighing and kneading of dough was up to 4.2-4.6 mg/m^3, on average, while at forming bread – 2.3 mg/m^3, on average. Massin [38] reported that in a big plant in Finland the highest concentrations were found while preparing the mixture for the dough. According to Burdorf [18], the mean level of exposure to dust at the workplace for mixing dough in Swedish bakeries was 5.5-7.5 mg/m^3 , and was higher than while kneading dough (2.5-2.7 mg/m^3), and ovens control (1.2-3.2 mg/m^3). In the studies carried out in bread bakery and cakes bakery, Burstyn [39] confirmed that the highest values were noted for sieving activities (8.2 mg/m^3), while in the studies by Elms [40] the highest mean geometric concentration of inhaled dust observed during sieving was 4.7 mg/m^3, during cleaning – 3.8 mg/m^3, and during kneading of dough 3.3 mg/m^3.

The studies conducted among students of a vocational school engaged in pasta manufacturing [24] showed an exposure to dust on the level from 0.20 – 0.70 mg/m^3 for PM_{10}, and from 0.33-0.82 mg/m^3 for $PM_{2,5}$.

The results of measurements of noise and dustiness in the plant manufacturing pasta in Italy [32] indicated that levels of dust concentration were lower than those recommended by the ACGIH as maximum allowed concentrations (0.5 mg/m^3). In this plant, low PM_{10} dust concentrations were observed (adopted by the researchers as inhaled dust), which ranged from 0.002 – 0.006 mg/m^3. Relatively higher levels (0.15 mg/m^3) were noted in the zone of pasta packaging, which resulted from work with a dried product. Moreover, short-term several-minute peaks in dust concentration were sometimes registered which, however, in no way exceeded the Threshold Limit Value for the Time Weighted Average (TLV-TWA) values for an 8-hour day of 0.5 mg/m^3. The occurrence of peaks were also confirmed in the studies by Nieuwenhuijsen conducted in bakeries and mills, where peak values were found within the range from 1.4-42.9 mg/m^3 [41]. In the presented study there also occurred peak values of concentrations; however, they exceeded the MAC values and affected the mean weighted values at individual workplaces, primarily during the kneading of dough on the manual line.

The presented study confirmed that during the manufacturing of dough the dust concentration was the highest, compared to other work activities (Tabs. 2, 4). Nevertheless, while comparing the results obtained with the data from literature, the fact should be considered that in the majority of these studies various methods of measurement and analysis were applied. It is also noteworthy that in various counties different maximum allowable concentrations of inhaled flour dust are adopted, from 0.5-10 mg/m^3.

CONCLUSIONS

Analysis of occupational conditions indicated that the physical load related with work activities performed by the employees at the workplaces examined was on a mediocre level. Evaluation of psychological load showed that on the automatic line this load remained on a mediocre or high level, while on the manual line it was on a low level.

At the same time, the evaluated factors of the material work environment (noise, lighting and microclimatic conditions) did not deviate from the allowable values contained in the standards, which indicate the provision of adequate work comfort conditions.

In the pasta manufacturing plant in the Lublin region the highest individual concentrations of inhaled and respirable dust were noted at the workplace of an operator of 'kneading dough', which is associated with conveying the flour for dough manufacturing. At this workplace, the MAC values were exceeded for inhaled dust, which requires further studies and the undertaking of actions in order to reduce employees' exposure to dust.

At the remaining workplaces on the manual line (operation of cutters, manual packaging), and at all workplaces on the automatic line (pasta manufacturing, operation of automatic packer), the MAC values for inhaled and respirable dust were not exceeded.

The employees engaged in work activities associated with the manufacturing of dough and packaging on the manual line are exposed to the most coarse particles of dust, which are removed from the airways. At these workplaces the highest percentage of non-thoracic fraction was observed, with a simultaneous, lowest percentage of respirable fraction.

At the workplace of an operator on the automatic line for pasta manufacturing, the highest percentage of thoracic, thoraco-bronchial, and respirable fraction in inhaled dust were noted, and the lowest percentage of non-thoracic fraction among all workplaces, which would mean that high exposure to the effect of the finest dust particles penetrating as far as to the alveoli.

It was found that in the pasta manufacturing plant the conditions with respect to dustiness in the environment are better, compared to mills [42].

A review of the relevant literature and evaluation of physical load at the workplaces examined have delineated the direction for further studies, related with hazards associated with musculoskeletal disorders and exposure to allergens present in cereal flour dust. This scope of problems will be undertaken in subsequent publications.

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