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CONTEMPORARY WORKING CONDITIONS AND ASSESSMENT OF OCCUPATIONAL HEALTH RISK FOR WORKERS EMPLOYED AT FLOUR-GRINDING PRODUCTIONS

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The paper gives a complex hygienic characteristics of working conditions at typical contemporary flour-grinding productions which deal with grain processing. It is shown that workers who are employed at flour-grinding production and perform their work tasks at all the stages of technological cycle on grain processing are exposed to a set of adverse industrial factors related to their labor process. These factors create hazardous working conditions which are ranked as having the 2nd and the 3rd hazard degree (3.2 and 3.3 categories) as per the Guide P 2.2.2006-05. Among primary factors which create hazardous working conditions we can mention flour dust; grain dust; industrial noise; adverse microclimate; labor hardness caused by overall high physical dynamic loads borne by arms, body, and legs; a necessity to stay in an inconvenient and forced working posture; constant moving related to maintenance of equipment and control over production processes. According to the Guide P 2.2.1766-03, categories of expected occupational health risk for workers are estimated to vary from average (substantial) risk to high (intolerable) one depending on functions performed by a worker. Working area air contamination with grain dust and flour dust are considered to be a priority health risk factor for workers employed at flour-grinding production. As we assessed occupational risks as per data obtained during periodical medical examinations, we detected an average authentic cause-and-effect relationship between working conditions factors and respiratory organs diseases (RR = 1.64; EF = 39 %, CI = 0.5–4.5), which meant such diseases were occupationally induced. Basing on the performed research, we developed priority measures which can help to reduce occupational health risks for workers employed at flour-grinding production.

***Key words**: workers employed at flour-grinding production; adverse working conditions; occupational health risk.*

Agricultural production is a key sphere in providing food security of any country; therefore, nowadays its development is a basic strategic task of the overall economic development in the Russian Federation. Flour-grinding production should be given special attention here since such food products as bread, grocery, macaroni, and cereals are manufactured out of grain and flour, and they traditionally account for a substantial part of an everyday ration consumed by population in Russia. Such products are indeed irreplaceable[1]. But still, most flour-grinding plants which operate in the country do not conform to any modern requirements in terms of their technical facilities. They were put into operation 30 or even 40 years ago and haven't undergone any substantial technical re-equipment since then; their basic production assets are out-of-date, and their wear and tear amounts to 62-70%. Technologies applied at such plants are also out-of-date, and production is not automated enough [1], that results in adverse working conditions existing at most workplaces there.

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[1] On the State program for the development of agriculture and regulation of markets for agricultural products, raw materials and food stuffs for 2013–2020: The RF Governmental Order dated July 14, 2012 N 717 [web-source]. – URL: http://docs.cntd.ru/document/902361843 (date of visit February 18, 2018).

According to a small number of scientific works available on the subject that were written at the end of the last century, working conditions at flour-grinding productions are related to several adverse industrial factors (grain dust, flour dust, in-plant noise, and uncomfortable microclimate) and labor process factors; these factors exert negative influence on workers' health [2–4]. Preliminary medical examinations revealed that workers employed at flour-grinding plants most frequently suffered from diseases in the respiratory organs, peripheral nervous system, musculoskeletal apparatus, cardiovascular system, and the gastrointestinal tract [2, 5]. Most research concentrated on examining dustiness in working area air caused by grain and flour dusts, peculiarities of emergence and clinical course of respiratory organs diseases, as well as efficiency of their treatment [6–10].

There hasn't been any complex research on working conditions that exist at production plants dealing with grain processing into flour. We haven't been able to find sufficient data on occupational risk assessment for workers employed at flour-grinding productions. There are no current data on occupational hygiene in flour-grinding production and it makes it difficult to develop and update standards and procedures aimed at providing hygienically safe working conditions and preventing health disorders in workers employed in this socially significant sphere. All the above-stated proves our research is essentially vital.

Our research goal was to give a hygienic characteristics of working conditions and to assess occupational risks for the health of workers employed at contemporary flour-grinding production.

Data and methods. We chose the following research object: working conditions existing at two flour-grinding plants with their daily production capacity being equal to 250 tons; these two plants functioned as structural units of an ordinary grocery plant. We examined air dustiness in working zones, parameters of industrial microclimate in warm and cold seasons, in-plant noise, overall vibration, labor hardness and intensity at all the stages in the technological process of processing grain into flour.

We analyzed air dustiness via gravity determination of dust mass; dust was collected out of a carefully measured volume of the examined air. Samples were collected on analytical paper filters in zones where workers breathed; samples collecting lasted from 5 to 10 minutes at a speed equal to 20 dm^3/minute. To obtain correct results at each sampling points, we repeated the collecting procedure 5 times. Mass concentration and component structure of dust were examined with conventional techniques and equipment. Assessment was performed as per average shift concentration of dust depending on how long a contact with it lasted and in full conformity with the existing hygienic standards. Disperse structure of dust was examined with PKVZ-905-1 air dustiness inspection tool, which is applied to automatically determine total solid particles count in an analyzed air volume (1000 ± 100 cm^3).

Microclimate parameters, noise and vibration were examined and assessed for standard technological processes in accordance with the Sanitary-Epidemiologic requirements No. 2.2.4.3359-16 entitled "Sanitary-Epidemiologic requirements to physical factors existing at workplaces"[2]. We applied measurement tools and procedures that were included into the State Register of measuring tools and that were properly calibrated.

We examined and assessed labor hardness and intensity in full conformity with P 2.2.2006-05 "Occupational hygiene. Guide on hygienic assessment of factors related to working environment and labor process. Criteria and classification of working conditions" (Supplements No. 15 and 16)[3]. Overall, we took 112 samples of dust, performed 376 examinations of

[2] 2.2.4.3359-16. Sanitary-epidemiologic requirements to physical factors existing at workplaces: Sanitary-epidemiologic rules and standards [web-source] // KODEKS: an electronic fund of legal and reference documentation. – URL: http://docs.cntd.ru/document/420362948 (date of visit April 11, 2018).

[3] P 2.2.2006-05. Guide on hygienic assessment of factors related to working environment and labor process. Criteria and classification of working conditions [web-source] // KODEKS: an electronic fund of legal and reference documentation. – URL: http://docs.cntd.ru/document/1200040973 (date of visit April 11, 2018).

physical factors related to working environment, and analyzed 21 jobs to get an insight into the essence of labor process at various workplaces.

Structure and categories of occupational risk were analyzed and assessed in full conformity with P 2.2.1766-03 "Guide on occupational health risks assessment. Organizational and methodical grounds, assessment procedures and criteria"[4].

We examined data of periodical medical examinations to assess workers' health; these examinations were performed by medical experts from Occupational Diseases Clinic at Rospotrebnadzor's Saratov Scientific Research Institute for Rural Hygiene. Our focus group was made up of 39 workers employed at grinding mills who were exposed to adverse industrial factors; their average age was 44.9 ± 4.1, and their average working experience in the sphere was 11.7 ± 3.5 years. Our reference group included 16 workers who were employed at plant offices and were not exposed to adverse industrial factors; their average age was 48.2±3.5, and their average working experience amounted to 9.8 ± 2.9 years. Workers in our focus group were raw materials loaders and grinding production operators; they performed their work tasks at various stages in the grain processing process. Loaders worked in raw materials loading sections; grain cleaners, in areas where grain was cleaned; roller operators, in rolling sections; millers and grinders, in grinding sections; packers, in sections where flour was packed. All the examined workers gave their informative consent to take part in our research in full conformity with biomedical ethics requirements.

We detected diseases related to working conditions in full conformity with principles of evidence-based medicine; to do it, we detected how strong a cause-and-effect relation existed between health disorders and work in accordance with P 2.2.1766-03[4], calculated relative risk parameters (RR) and etiological fraction (EF) that belonged to a contribution made by occupational factors into pathology development. We applied 95% confidence interval (CI) to assess validity of the obtained data.

Hygienic research results were statistically processed with Microsoft Office-2007 (MS Excel-07) software application and Statistica 10.0 software.

Results and discussion. A technological process applied for processing grain into flour includes a lot of stages, is rather complicated, power-operated and automated; it is a continuous process which should flow uninterruptedly. The basic stages of the process are consequent and interrelated; they include formation of grain into separate batches for further grinding (raw materials section); grain cleaning from admixtures and preparation for grinding (rolling section); grain grinding into flour and detection of flour grade (grinding section); flour packing into sacks (packing section). This technological process has its peculiarities; to be exact, it involves application of multiple equipment, including sealed one with aspiration of its interior volumes. The examined plants applied such equipment as air conveyors, mechanic transport (bucket conveyors and conveyor tracks) as well as gravity lines, to transport grain, intermediate grinding products, finished products, and production wastes. The equipment was handled, adjusted and controlled semi-automatically and automatically, and partially it involved remote control performed on computerized control desks.

The research results revealed that air contamination with organic dusts of raw materials, intermediate products, and finished products, was a leading adverse factor at contemporary flour-grinding production. Air dustiness was primarily caused by:

– inefficient work of dust removing systems;

– equipment that transports, cleans, or grinds grain and products made of it not being properly sealed;

– absence of tightness at junctions of grain and flour lines with bucket conveyors;

– equipment which can cause dustiness not being properly covered.

[4] P 2.2.1766-03. Guide on occupational health risks assessment. Organizational and methodical grounds, assessment procedures and criteria [web-source] // KODEKS: an electronic fund of legal and reference documentation. – URL: http://docs.cntd.ru/document/901902053 (date of visit April 11, 2018).

Table 1

Hygienic characteristics of occupational factors related to workplaces of workers employed at flour grinding production

Occupational groups	Occupational factors				
	grain dust, mg/m^3	flour dust, mg/m^3	noise, equivalent level of sound, dB	average shiftя equivalent air temperature, °C (cold season)	average shiftя equivalent air temperature, °C (warm season)
Grain cleaners	11.29 ± 2.4	–	82 ± 0.79	11.9 ± 1.7	17.9 ± 1.2
Millers	12.0 ± 4.4	–	83 ± 0.91	11.6 ± 0.9	18.9 ± 1.9
Roller operators	–	16.5 ± 4.1	84 ± 0.84	12.4 ± 0.78	18.3 ± 1.45
Grinders	–	9.7 ± 2.1	83 ± 0.78	12.4 ± 1.05	18.3 ± 1.45
Packers	–	34.6 ± 4.3	78 ± 0.67	13.8 ± 1.11	18.5 ± 1.4
Loaders	20.8 ± 2.8	–	78 ± 1.56	13.5 ± 0.56	17.2 ± 0.9
Permissible values	4	6	80	14.0–22.0	16.0–27.0

We examined the air in zones where workers employed at flour-grinding production had to breathe; our research was focused on dust contents in the air in these zones and it revealed that a type of dust and its quantitative contents depended on a particular stage in the technological process of grain processing (Table 1).

As we can see from the table, dustiness of working area air was higher than maximum permissible concentrations (MPC) at workplaces of workers from all the occupational groups existing at flour-grinding production.

We detected that grain dust which could be found in working area air at flour-grinding production mixed with free silicon dioxide (SiO_2), the fraction of which being from 10 to 40 %. This compound is the most adverse in terms of pathology emergence in the respiratory organs [10, 11]. Depending on a section, grain dust consists of particles with their size up to 5 μm and with their share varying from 59.0 to 87.6%. Such particles have the greatest penetrability. Flour dust is organic, and 95% of it are also particles with their size being up to 5 μm in the analyzed air volume (1000 ± ± 100 cm^3). According to data taken from literature, grain and flour dust can also contain pollen of various plants, microscopic fungi from such stems as *Penicillium, Aspergillus, Fusarium, Tilletia* etc., bacteria from such stems as *Staphylococcu* and *Streptococcus;* all these admixtures can cause allergic, fungi, or bacterial pathologies in workers' respiratory organs [5, 12–14]. Grain can also contain chemicals (formaldehyde) and pesticides after it has been treated and gassed [10].

In-plant noise generated by machinery, tools, transport equipment, and ventilation systems, is another adverse occupational factor which is specific for flour-grinding production and which can cause adverse effects on workers' health [15, 16]. Noise that was registered in working zones at flour-grinding plants was constant and broadband; its levels depended on equipment. The highest noise levels (104.0 ± 0.72 dB) that exceeded maximum permissible one and could be heard within the overall audible range, excluding 63 Hz frequency, were registered at workplaces of workers in the roller section near rolling machinery. Noise levels produced by compressor units which were used as drivers for air conveyors moving products inside a workshop reached 101.8 ± 0.48 dB; they exceeded maximum permissible levels at frequencies equal to 63-8,000 Hz. Noise levels which occurred in grain cleaning workshops near separators and cleaning machinery ranged within 87-95 dB, exceeding maximum permissible levels at frequencies equal to 250-8,000 Hz. Noise levels detected in soundproof control cabins didn't exceed maximum permissible levels (80 dB). Equivalent noise levels calculated for an overall work shift were not more 5 dB higher than maximum permissible levels taking into account overall time which workers spent in zones where the equipment was

maintained. So, such conditions could be ranked as adverse ones with the 1st hazard category, class 3.1 (table 1). We also registered vibration in grinding sections but its adjusted level didn't exceed maximum permissible one (class 2).

A cooling microclimate usually occurred in working zones of flour-grinding plants during a cold season. The lowest air temperatures in working zones were detected at upper floors of grain cleaning sections. The temperature there went down to 8°C which was 7°C lower that permissible levels for working conditions (IIa) fixed for operators at flour-grinding productions. But at the same time, average shift equivalent air temperature amounted to 11.9° C –13.8 ± 1.11 taking into account overall time which workers had to spend in workshops with cooling microclimate inside them; such working conditions were estimated as having the 1st hazard category (class 3.1).

Air speed was higher than the standard in all seasons and in all the workshops (up to 1.4-1.6 m/sec against 0.2-0.4 m/sec). It could make effects caused by low air temperatures even worse and cause peripheral neurovascular disorders, hypertension, respiratory diseases and diseases in the peripheral nervous system [17].

Labor hardness for workers employed at flour-grinding plants was determined by peculiarities of working tasks performed by various occupational groups. Grain cleaners, millers, roller operators, and grinders handled control and measuring instruments and dealt with maintenance of various equipment installed at different floors. Therefore, they had to constantly moved from one place to another covering a distance of more than 8 km horizontally and up to 2.5 km vertically. They also had to eliminate jams which occurred when grain and products of its processing moved through gravity lines; they had to do it in forced working postures and overall time spent by them in such postures amounted to 7-10% of their overall shift. The total time spent in an uncomfortable posture didn't exceed 25% of a shift; a number of forced body bendings which exceeded 30° was from 100 to 300 per a shift. Packers who packed flour into sacks, sewed sacks up, and cleaned their workplaces, had to work in a fixed uncomfortable working posture from time to time (up to 25% of a shift). Labor of loaders employed at warehouses where raw materials and finished products were stored involved manual and partially mechanical lifting and moving of cargoes with weight exceeding 35 kg (3.2 hazard class). A number of forced body bendings exceeding 30° was from 51 to 100 per a shift (2 class). Overall assessment of working conditions as per labor hardness corresponded to hard 3.2 hazard class labor for loaders, grain cleaners, and packers; hard 3.1 hazard class labor, for millers, roller operators, and grinders. Hard labor is known to cause functional overstrain of workers' bodies and it can lead to occupational diseases in the peripheral nervous system and the musculoskeletal apparatus [18, 19].

Labor intensity for workers at all the stages in the technological process existing at flour-grinding production (loaders excluded) involved total operational loads (up to 75% of a shift), high sensory loads and loads on their hearing apparatus that resulted from increased noise levels. Work was organized in 3 day shifts and 1 night one; each shift was 12 hours long. Labor intensity for workers from all the occupational groups was assessed as being permissible (average hazard degree, class 2).

The total assessment of working conditions for workers employed at flour-grinding production which took into account the overall set of occupational factors and labor process factors allows to rank them as hazardous, having 2 and 3 hazard category (3.2 and 3.3 classes) depending on a type of work performed (table 2).

We assessed occupational risks basing on the results of quantitative assessment of exposure to occupational factors (as per working conditions classes) in conformity with the criteria set forth in the Guide P 2.2.1766-03[4]. This assessment was based on determination of expected occupational risk category. We detected that a priori risk for the health of flour-grinding production operators caused by exposure to adverse occupational factors varied from average (substantial) to high (intolerable) depending on a stage in the technological process.

Table 2

Hygienic assessment of working conditions and occupational health risks for workers employed at various stages of the technological process existing at flour-grinding production

Occupational groups	Factors related to working conditions					Overall estimate	Occupational risk category
	APFE	micro-climate	noise	labor hardness	labor intensity		
Grain cleaners	3.1	3.1	3.1	3.2	2	3.2	Average (substantial) risk
Millers	3.1	3.1	3.1	3.1	2	3.2	
Roller operators	3.1	3.1	3.1	3.1	2	3.2	
Grinders	3.1	3.1	3.1	3.1	2	3.2	
Packers	3.1	3.1	2	3.2	2	3.2	
Raw materials loaders	3.2	3.1	2	3.2	2	3.3	High (intolerable) risk

Note: APFE means aerosols with primarily fibrogenic effects

To estimate effects exerted by working conditions on workers' health as per results obtained in the course of periodical medical examinations, we calculated relative risk (RR) and etiological fractions (EF) of contribution made by occupational factors into diseases emergence. As a result we revealed an average cause-and-effect relation between respiratory organs diseases and work (RR = 1.64; EF = 39 %, CI = 0.5–4.5); that means that such diseases are occupational ones.

The performed research gave grounds for determining priority measures aimed at reduction of occupational risks for health of workers employed at flour-grinding production. First of all, such measures should include advanced development of both technology and equipment. Unfortunately, dustiness in working zones cannot be eliminated completely at contemporary flour-grinding production; therefore, it is especially important to implement technical, sanitary-hygienic, and medical-preventive activities at such plants. Here we can primarily mention the following: maximum possible automation and sealing of equipment, control over dustiness in working zones, strict adherence to scheduled dates of equipment maintenance and overhaul, and implementation of more rational work and leisure regimes (time-based protection). Timely periodical medical examinations, preventive and rehabilitation activities also play very important part in the process.

Our research allowed us to come to the following **conclusions:**

1. Workers employed at flour-grinding production are exposed to a set of adverse occupational factors at their work places; these factors create hazardous working conditions of the 2nd and 3rd hazard category (classes 3.2 and 3.3).

2. Occupational health risks for workers are estimated to be either average (substantial) or high (intolerable) depending on work tasks performed by workers.

3. There is an authentic average cause-and-effect relation between respiratory organs diseases and work; that means such diseases are occupational.

When any managerial decisions are made on minimization of occupational health risks for workers employed at flour-grinding production, the most important thing is to prevent negative effects exerted by dustiness in working zones.

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