ХИМИЧЕСКИЕ И ФАРМАЦЕВТИЧЕСКИЕ ТЕХНОЛОГИИ. БЕЗОПАСНОСТЬ ЖИЗНЕДЕЯТЕЛЬНОСТИ

DOI: https://www.doi.org/10.53002/131

ANALYSIS OF SPECIFIC HAZARDS OF CONFECTIONERY PRODUCTION

Lavrentieva* A.E., Chernysheva A.A., Lekhtmetz V.L., Kornev V.V., Al Azzam K.M.

Karaganda Industrial University, Temirtau, Kazakhstan
** Corresponding author email: a.lavrentyeva@tttu.edu.kz*

Author information:
Lavrentieva A.E. - Karaganda Industrial University, Temirtau, Kazakhstan. E-mail: *a.lavrentyeva@tttu.edu.kz*
Chernysheva A.A. - Karaganda Industrial University, Temirtau, Kazakhstan.
Lekhtmetz V.L. - Karaganda Industrial University, Temirtau, Kazakhstan.
Kornev V.V. - Karaganda Industrial University, Temirtau, Kazakhstan.
Al Azzam K.M. - University of Jordan, Jordan

Abstract. Confectionery production, despite belonging to the food industry, may include areas with signs of increased industrial danger (dust-air mixtures, hot processes, intensive mechanization), which requires a systematic risk analysis and management measures. The specifics of the hazards are caused by a combination of complex thermal processes, the use of powerful mechanical equipment, and, most critically, work with dispersed systems of organic origin. Taking into account the requirements of the Law of the Republic of Kazakhstan "On Civil Protection", the management of these hazards is a key task to prevent accidents and ensure occupational safety. The article provides a comprehensive analysis and classification of specific production hazards typical of the confectionery industry of the Republic of Kazakhstan.
Keywords*:* confectionery production, industrial safety, dust and explosion hazard, risk analysis, labor protection, dust and air mixtures, industrial injuries.

КОНДИТЕРЛІК ӨНДІРІСТІҢ ЕРЕКШЕ ҚАУІПТЕРІН ТАЛДАУ

Лаврентьева* А.Е., Чернышева А.А., Лехтмец В.Л., Корнев В.В., Аль-Аззам Х.М

Қарағанды Индустриялық Университеті, Теміртау, Қазақстан
** Автор-корреспондент e-mail: a.lavrentyeva@tttu.edu.kz*

Авторлар туралы ақпарат:
Лаврентьева А.Е. - Қарағанды Индустриялық Университеті, Теміртау, Қазақстан. E-mail: *a.lavrentyeva@tttu.edu.kz*
Чернышева А.А. - Қарағанды Индустриялық Университеті, Теміртау, Қазақстан.
Лехтмец В.Л. - Қарағанды Индустриялық Университеті, Теміртау, Қазақстан.
Корнев В.В. - Қарағанды Индустриялық Университеті, Теміртау, Қазақстан.
Әл-Аззам Х.М. – Иордания университеті, Иордания

Аңдатпа. Кондитерлік өнімдер тамақ өнеркәсібіне жататынына қарамастан, өнеркәсіптік қауіптіліктің жоғарылау белгілері бар учаскелерді қамтуы мүмкін (шаң-ауа қоспалары, ыстық процестер, қарқынды механикаландыру), бұл тәуекелдерді жүйелі талдауды және оларды басқару шараларын қажет етеді. Қауіптің ерекшелігі күрделі жылу процестерінің үйлесуіне, қуатты механикалық жабдықты пайдалануға және, ең бастысы, органикалық дисперсті жүйелермен жұмыс істеуге байланысты. ҚР "Азаматтық қорғау туралы" Заңының талаптарын ескере отырып, бұл қауіптерді басқару авариялардың алдын алу және еңбек қауіпсіздігін қамтамасыз ету үшін негізгі міндет болып табылады. Мақалада Қазақстан Республикасының кондитерлік саласына тән ерекше өндірістік қауіптерге кешенді талдау және жіктеу жүргізіледі.
Түйін сөздер*:* кондитерлік өндіріс, өнеркәсіптік қауіпсіздік, шаң жарылыс қаупі, тәуекелдерді талдау, еңбекті қорғау, шаң-ауа қоспалары, өндірістік жарақаттану.

АНАЛИЗ СПЕЦИФИЧЕСКИХ ОПАСНОСТЕЙ КОНДИТЕРСКОГО ПРОИЗВОДСТВА

Лаврентьева* А.Е., Чернышева А.А., Лехтмец В.Л., Корнев В.В.

[1]Карагандинский индустриальный университет, Темиртау, Казахстан
** Автор-корреспондент e-mail: a.lavrentyeva@tttu.edu.kz*

Информация об авторах:
Лаврентьева А.Е. - Карагандинский индустриальный университет, Темиртау, Казахстан. E-mail: *a.lavrentyeva@tttu.edu.kz*
Чернышева А.А. - Карагандинский индустриальный университет, Темиртау, Казахстан.
Лехтмец В.Л. - Карагандинский индустриальный университет, Темиртау, Казахстан.
Корнев В.В. - Карагандинский индустриальный университет, Темиртау, Казахстан.
Аль-Аззам Х.М. – Университет Иордании, Иордания.

Аннотация. Кондитерское производство, несмотря на принадлежность к пищевой отрасли, может включать участки с признаками повышенной промышленной опасности (пылевоздушные смеси, горячие процессы, интенсивная механизация), что требует систематического анализа рисков и мер управления ими. Специфика опасностей обусловлена сочетанием сложных тепловых процессов, использованием мощного механического оборудования и, что наиболее критично, работой с дисперсными системами органического происхождения. С учетом требований Закона РК "О гражданской защите", управление этими опасностями является ключевой задачей для предотвращения аварий и обеспечения безопасности труда. В статье проводится комплексный анализ специфических производственных опасностей, характерных для кондитерской отрасли Республики Казахстан.
Ключевые слова: кондитерское производство, промышленная безопасность, пылевзрывоопасность, анализ рисков, охрана труда, пылевоздушные смеси, производственный травматизм.

MAIN PROVISIONS

Confectionery production is characterized by a combination of dust-explosion, thermal, mechanical, electrical, and organizational risk factors that require a comprehensive approach to industrial safety management. The most significant hazard is posed by dust-air mixtures generated during the handling of flour, powdered sugar, cocoa powder, and other dispersed organic materials. Effective reduction of occupational risks is achieved through the implementation of technical protective measures, regular monitoring of equipment condition, compliance with occupational health and safety management system requirements, and improvement of personnel training. The presented classification of specific hazards can be used in occupational risk assessment, the development of occupational safety measures, and the improvement of industrial safety management systems at confectionery enterprises in the Republic of Kazakhstan.

INTRODUCTION

The Republic of Kazakhstan has several large-scale confectionery production facilities operating on an industrial scale. Among the major enterprises are JSC “LOTTE Rakhat” (Almaty) and JSC “Bayan Sulu” (Kostanay), as well as other companies mentioned among the country's leading confectionery manufacturers, such as Hamle [1, 2].

Such production facilities are characterized by large volumes of storage and transportation of bulk raw materials, including sugar, flour, and cocoa products; extensive aspiration systems; and numerous forming and packaging lines. These factors make the risks of dust explosions, fires, and occupational injuries not merely theoretical but practical concerns. The principal specific hazard in confectionery production is the explosiveness of flour and sugar dust (dispersed systems). Flour, powdered sugar, starch, and cocoa powder are organic substances that, when finely dispersed and mixed with air, can form a combustible and explosive dust-air mixture.

The confectionery industry is one of the most dynamically developing sectors of the food industry and plays an important role in supplying the population with food products, developing the processing sector, and creating employment opportunities. At the same time, confectionery production processes are characterized by a combination of various occupational factors that may pose potential hazards to workers and production infrastructure. The use of bulk organic raw materials, high-temperature equipment, mechanized production lines, and complex engineering systems necessitates a comprehensive approach to ensuring industrial and occupational safety.

In recent years, occupational risk management has become increasingly relevant due to the transition of enterprises toward risk-oriented occupational safety management systems based on the prevention of accidents and occupational injuries. The

international standard ISO 45001:2018, as well as modern approaches to occupational risk management, provides for the systematic identification of hazards, assessment of the probability of their occurrence, and development of preventive measures aimed at reducing occupational risks.

For confectionery enterprises in the Republic of Kazakhstan, the most common hazards include those associated with the formation of dust-air mixtures, exposure to high temperatures, operation of mechanized equipment, electrical hazards, and organizational deficiencies in occupational safety management. Although individual aspects of industrial safety in food-processing facilities have been widely addressed in the scientific literature, issues related to the comprehensive classification of specific hazards in confectionery production, taking into account the characteristics of domestic enterprises, have received insufficient attention.

This study aims to analyze and systematize the specific occupational hazards characteristic of confectionery enterprises in the Republic of Kazakhstan and to identify the main areas for improving the effectiveness of industrial safety and occupational health management systems.

Scientific novelty. The study systematizes and classifies the specific occupational hazards characteristic of confectionery enterprises in the Republic of Kazakhstan. Particular attention is paid to dust-explosion hazards, thermal, mechanical, electrical, and organizational risks, taking into account modern industrial safety and occupational health requirements.

Practical significance. The findings can be used in occupational risk assessment, the development of occupational safety measures, improvement of industrial safety management systems, and personnel training at confectionery enterprises.

MATERIALS AND METHODS

Study design. The work was conducted as a qualitative narrative review with elements of comparative analysis. The evidence base comprised the legal, standardization, and scientific sources included in the reference list and addressing industrial safety, occupational hygiene, ergonomic risk, and occupational health and safety management in food and confectionery production.

Analytical procedure. Information from the selected sources was extracted and organized according to four attributes: the source of the hazard, the mechanism by which it may be realized, the possible consequences for personnel or infrastructure, and the corresponding preventive controls. Related hazards were then consolidated into categories and compared with typical operations used at industrial confectionery enterprises, including storage and transfer of bulk raw materials, thermal processing, forming, packaging, equipment cleaning, and maintenance.

Scope and limitations of the method. The analysis was qualitative and did not include site inspections, instrumental measurements, accident-frequency calculations, or statistical estimation of risk. Accordingly, the classification identifies priority hazard groups and control directions but does not provide enterprise-specific probability or severity scores.

RESULTS

The analysis identified five interrelated groups of hazards: dust-explosion; thermal and fire; mechanical; electrical and workplace-environment; and organizational hazards. Their mechanisms, likely consequences, and principal preventive measures are presented below.

Mechanism of the Hazard. An explosion occurs when the concentration of dust in the air reaches the Lower Explosive Limit (LEL) and an ignition source is present, such as a spark caused by static electricity, an overheated bearing, or faulty electrical equipment. The main critical areas include:

Aspiration and filtration systems, where dust becomes concentrated.

Hoppers and silos used for storing bulk products.

Mills and screening machines, which generate the largest quantities of dust.

At large-scale factories such as JSC “LOTTE Rakhat” in Almaty and JSC “Bayan Sulu” in Kostanay, bulk ingredients are often transferred to screening and dosing systems through hoppers and material-transfer areas.

A typical scenario for the formation of a hazardous dust-air mixture occurs when raw materials are transferred, including during the opening of bags and feeding materials into receiving hoppers, while general ventilation carries dust into the working area and screening equipment increases dust concentration at the inlet and outlet. Potential ignition sources may include local equipment defects, such as sparking electric motors, overheating bearing assemblies, or electrostatic discharge from flexible hoses and material-transfer sections.

The consequences of a dust explosion include the destruction of equipment and structures, as well as the risk of a secondary explosion. A primary explosion in an aspiration or material-transfer area can lift accumulated dust from upper surfaces such as beams, trays, and air ducts, after which the fire rapidly spreads throughout the room, significantly increasing the damaging effects. Therefore, for confectionery production facilities in the Republic of Kazakhstan, not only the proper functioning of aspiration systems and electrical equipment is critical, but also systematic cleaning of hard-to-reach areas [1].

In addition to the explosion hazard posed by fine

dust, thermal and fire hazards constitute a significant class of risks in confectionery production. Fire hazards are associated with the extensive use of high-temperature processes and the storage of combustible materials. The operation of ovens, cooking units, and syrup-processing systems requires continuous monitoring of thermal conditions, since exceeding permissible parameters may result in ignition of raw materials, lubricants, or heat-transfer fluids. Furthermore, large stocks of fats, oils, and packaging materials such as cardboard and polymers represent a significant fire load. In the event of a fire, rapid flame propagation may be aggravated by air ducts and ventilation systems, requiring strict compliance with fire-resistance requirements for structures and the availability of effective automatic fire-extinguishing systems.

At enterprises with a wide product range, including chocolate, biscuits, caramel, and wafers, packaging and container storage areas effectively constitute separate zones of increased fire load. This is particularly evident where cardboard and polymer packaging materials are stored in large quantities near areas of intensive shipping operations, such as loading gates and ramps. Under such conditions, a single localized overheating event—for example, caused by a defective cable, lighting fixture, equipment charging station, or ventilation fan motor—can result in rapid fire development due to the high combustible load of these materials.

High temperatures are also directly associated with the risk of thermal injuries. In cooking, tempering, and forming areas, there is a high probability of severe burns caused by hot syrups, molten fats, steam, or contact with heated equipment surfaces. This requires not only the use of personal protective equipment (PPE), but also the insulation of hot equipment components and the implementation of automatic pressure and temperature control systems [3].

For caramel and syrup-processing areas, which are characteristic of large confectionery factories, including facilities in Kostanay, a typical risk is associated not only with “hot surfaces” but also with the release of hot product when process conditions are violated.

For example, partial blockage of a pipeline or improper operation of shut-off valves may result in sudden depressurization or ejection of hot syrup when the flow is switched toward the forming equipment. In such situations, an injury can occur within seconds, making organizational measures—such as clear switching procedures and prohibiting manual operations within potential discharge zones—as critical as the use of PPE.

Mechanical hazards are common to any large industrial enterprise and are associated with the operation of high-performance, rapidly moving equipment. At confectionery factories, this class of risks is particularly pronounced in areas involving mixing, dosing, forming, and packaging operations [4].

Hazards Associated with Rotating and Moving Parts

Equipment such as dough mixers, industrial mixers, rolling mills, and conveyor systems creates a constant risk of clothing or body parts being caught in moving mechanisms, which can result in bruises, fractures, and, in severe cases, amputations. To minimize this risk, it is essential to ensure the full operability of protective guards and interlocking devices that prevent equipment from starting when access to a hazardous zone is possible.

A typical injury scenario on forming and packaging lines involves an attempt to perform “quick cleaning” without completely stopping the equipment and isolating its energy sources. A worker may remove product residue from rollers or augers or adjust jammed film on a conveyor, assuming that the equipment is moving slowly. However, the machinery may suddenly jerk due to automatic operation, a product sensor, or an automatic restart following a temporary stop.

At high-capacity factories, including major facilities in Almaty and Kostanay, the problem is exacerbated by the continuous operation of production lines and the pressure on personnel to avoid interrupting production.

Hazards Associated with Storage and Handling of Loads.

In warehouses and picking areas, there is a risk of stacked goods collapsing, products falling from heights, and collisions with industrial vehicles. These risks require strict compliance with storage and stacking schemes, regular inspection of storage racks, and mandatory training and certification of personnel operating lifting and transport equipment [4].

Work-at-Height Hazards. The risk of falling from height arises during repair work, cleaning, and maintenance of large stationary structures such as silos, raw-material hoppers, and ventilation systems. This requires strict compliance with work-at-height safety rules, the use of fall-arrest systems, and properly designed scaffolding and work platforms.

The occupational health and industrial safety management system must also take into account risks associated with adverse workplace environmental factors [5].

Electrical Hazards. The presence of large quantities of electrical equipment, including powerful motors and heating elements, creates a risk of electric shock due to damaged insulation, inadequate grounding, or errors during maintenance. These risks are significantly increased in areas with high

humidity, such as equipment-washing facilities, requiring the use of reduced-voltage systems and residual current devices (RCDs).

Noise and Vibration. Continuous operation of high-performance machinery, ventilation, and aspiration systems generates significant levels of occupational noise and vibration. Prolonged exposure to these factors may result in occupational diseases, including hearing loss [3]. Risk control requires the use of sound-absorbing materials, PPE such as earmuffs and earplugs, and regular occupational exposure monitoring.

Microclimate. Temperature and humidity levels in different production areas may be uncomfortable or even hazardous. For example, oven areas are characterized by high temperatures, whereas cold-storage chambers may have extremely low temperatures. This requires regulation of the duration of personnel exposure and the provision of appropriate protective clothing.

In equipment-washing areas, the risk is often associated not with permanently installed electrical cabinets but with portable devices, including extension cords, portable lamps, mobile pumps, and foam generators. Under conditions of wet floors and condensation, even a minor crack in insulation or a "temporary" connection made without proper control can result in electric shock. In practice, this requires a separate procedure governing the use of portable electrical equipment in washing areas, including equipment identification, periodic inspection, and a prohibition on improvised extension cords.

Accident analysis indicates that a significant proportion of incidents are caused not by technical failures but by organizational deficiencies or human factors.

*Deficiencies in the Industrial Safety Management System.*These include the absence or ineffectiveness of the management system, irregular monitoring, and a formal approach to documentation. For example, a dust-cleaning log may be maintained merely "for inspection purposes" while failing to cover upper areas and internal cavities of aspiration systems, resulting in dust accumulation in hard-to-reach locations [5].

Personnel Errors. Personnel errors include violations of established procedures and bypassing safety interlocks, including failure to follow energy-isolation procedures during maintenance. A typical scenario involves stopping equipment using only the control button without locking out the power supply at the electrical cabinet, after which another employee starts the production line based on a "ready" indication.

Insufficient Training. Personnel may know how to respond to an ordinary fire but may not understand the specific characteristics of dust explosions or the critical importance of isolating energy sources before entering a hazardous area.

DISCUSSION

The findings show that confectionery production should not be treated solely as a low-hazard food processing activity. The simultaneous presence of combustible organic dust, ignition sources, hot processes, rapidly moving equipment, and intensive logistics creates interacting accident scenarios. This interpretation is consistent with the industrial-safety and occupational-health principles reflected in the cited legal and scientific sources [1–5].

Dust-explosion hazards require particular attention because a local ignition in aspiration, screening, or material-transfer equipment may be followed by a secondary explosion involving settled dust. Therefore, ventilation alone is insufficient: effective control also depends on preventing dust accumulation, eliminating ignition sources, grounding equipment, monitoring bearings and electrical components, and maintaining effective housekeeping procedures.

The analysis also indicates that technical safeguards and organizational controls are mutually dependent. Guards, interlocks, residual current devices, insulation, and automatic monitoring reduce risk only when maintenance, sanitation, and energy-isolation procedures are consistently followed. For occupational safety management, the proposed classification can therefore be used as a preliminary checklist for hazard identification and for planning enterprise-level risk assessments.

The study has limitations. It is based on a limited narrative evidence base and does not include field measurements, enterprise accident records, worker exposure data, or quantitative risk-ranking methods. The conclusions should therefore be verified at individual facilities through inspections, measurement of workplace factors, analysis of incident data, and formal assessment of risk probability and severity.

CONCLUSION

Confectionery production combines several groups of risks arising simultaneously from raw materials, technological processes, and work organization. The most critical risks for enterprises in the Republic of Kazakhstan include dust-explosion hazards associated with the handling of bulk ingredients, fire hazards in packaging warehouses and intensive logistics areas, and the risk of injuries during the operation and maintenance of mechanized production lines.

The qualitative synthesis indicates that the severity of consequences depends not only on the presence of a hazard but also on the quality of safety management, including the proper functioning of aspiration and electrical systems, disciplined cleaning

practices, procedures for equipment shutdown and energy isolation, and the level of personnel training.

Therefore, the priority areas for improving safety include technical measures aimed at preventing dust accumulation and eliminating ignition sources, organizational standardization of work processes—including maintenance and sanitation operations—and regular personnel training with practical exercises based on typical emergency scenarios.

Such an approach makes it possible to reduce the probability of accidents and injuries without compromising production efficiency and ensures compliance with industrial and fire safety requirements.

Author Contributions (CRediT Taxonomy)

A.E. Lavrentyeva – conceptualization of the study, development of the methodology, analysis of the scientific literature, systematization and classification of occupational hazards, and preparation of the initial manuscript draft.

A.A. Chernysheva – investigation, collection and analysis of regulatory and technical information, validation of the results, and participation in the preparation and editing of the manuscript.

V.L. Lekhtmets – formal analysis, visualization of materials, critical review, and editing of the manuscript.

V.V. Kornev – supervision of the research, project administration, review, and final approval of the manuscript for publication.

All authors have read and approved the final version of the manuscript for publication.

*Funding.*The study was conducted without external funding.

Conflict of Interest. The authors declare that they have no conflict of interest.

Acknowledgments. The authors express their gratitude to Karaganda Industrial University for the support provided during the research.

REFERENCES

[1] Law of the Republic of Kazakhstan No. 188-V dated April 11, 2014. On Civil Protection (as amended and supplemented through 2025).

[2] Abzalieva S.A., Sarsenova A.O., et al. Social and hygienic review of the current state of the leading industries of the Republic of Kazakhstan. Gigiena i Sanitariya (Hygiene and Sanitation). 2016;95(8):748–754. (In Russ.).

[3] Bafoyev A.H. Hygiene Issues Among Workers in Confectionery Production Enterprises. Journal of Modern Educational Innovations. 2023;2(4):45–52.

[4] Kim I.J. Safety and Health Practices in the Food Industry and Ergonomic Interventions. Journal of Ergonomics. 2016;6(4):178.

[5] International Organization for Standardization (ISO). ISO 45001:2018. Occupational health and safety management systems — Requirements with guidance for use. Geneva: ISO; 2018.