Шановна професійна спільнота зернопереробної галузі!

Виповнюється 25 років з дня виходу у світ першого номеру науково-виробничого журналу «Зернові продукти і комбікорми». За 25 років безперервно, чотири рази на рік, вийшло 100 номерів журналу! Я вітаю колектив Одеського національного технологічного університету, колектив редакційної колегії і всіх користувачів цього журналу з ювілеєм!

Це не просто ювілей, це свідчення стійкості і незламності науковців і виробничників, високого рівня здобутків наукових шкіл з технології зберігання і переробки зерна, технології хлібопекарських виробництв, технології виробництва комбікормів, кормових добавок і premіксів. На сторінках ста номерів ви публікували головні наукові досягнення і ділились кращим виробничим досвідом, висвітлювали важливі науково-технічні та інноваційно-технологічні новини.

Журнал «Зернові продукти і комбікорми» став платформою наукового супроводу і розвитку зернопереробної, хлібопекарної та комбікормової галузей України, інформаційним партнером головних конгресів, конференцій, самітів та інших Всеукраїнських і міжнародних галузевих заходів. З 2019 року журнал виходить також англійською мовою, що розширює горизонти міжнародної співпраці.

Висловлюю вдячність всім, хто підтримував всі ці роки журнал «Зернові продукти і комбікорми» і сподіваюсь, що підтримка продовжиться! Робота журналу показала наскільки важливо попри всі обставини і негаразди об'єднуватися заради розвитку зернової галузі, процвітання України та зміцнення її продовольчої безпеки.

Одеський національний технологічний університет вже 123 роки готує фахівців для зернової галузі, забезпечує її науковий супровід, розробляє і впроваджує сучасні технології, обладнання і системи управління і ось вже 25 років забезпечує інформаційну підтримку розвитку профільних підприємств.

Висловлюю вдячність колективу Одеського національного технологічного університету, колективу редакційної колегії, головному редактору журналу д.т.н., професору, академіку НААН України Богдану Єгорову і д.т.н., зав. каф. технології зерна і комбікормів Аллі Макаринській за велику роботу з інформаційної підтримки однієї з базових галузей економіки України. Бажаю всім мирного неба, творчого натхнення і подальших успіхів у цій важливій справі!

Міністр економіки, довкілля та
сільського господарства України **Олексій СОБОЛЕВ**

UDC 664:658.562:614.31
DOI https://doi.org/10.15673/gpmf.v26i1.3392

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SYSTEMATIC APPROACHES TO FOOD SAFETY AND QUALITY CONTROL

Abstract

A systematic approach to organizing control at all stages of production plays an important role in ensuring food safety and quality. The modern development of the food industry, the expansion of global supply chains, growing consumer demands for product quality, and stricter international safety standards necessitate the improvement of approaches to risk management in industrial food production. Ensuring an adequate level of product safety requires quality control of the finished product and systematic management of potential hazards at all stages of the production process: from the supply of raw materials to the sale of finished products. Modern approaches to the organization of food safety and quality control in industrial production are considered. Particular attention is paid to a systematic approach to the classification of types of control according to the nature of possible hazards and stages of the production process. The main categories of risks that may arise during food production, in particular biological, chemical, and physical hazards, are analysed, and the features of their control within the technological processes of food industry enterprises are determined. The study aims to systematize the types of food safety and quality control in industrial production and determine their role in the formation of an effective risk management system. The features of the organization of incoming control of raw materials, technological control during production, control of finished products, and sanitary and hygienic control of the production environment are considered. It has been established that the combination of different types of control and their integration into the food safety management system contributes to increasing the efficiency of the production process, minimizing the risks of hazardous factors, and ensuring stable product quality. The implementation of a systematic approach to food safety and quality control ensures comprehensive risk management, increases consumer confidence in products, and contributes to the competitiveness of food industry enterprises in domestic and international markets. The use of integrated food safety management systems, the introduction of modern technologies for monitoring production processes, and the improvement of control procedures create the conditions for improving the efficiency of enterprises and ensuring the sustainable development of the food industry.

Keywords: safety management; food safety; HACCP; systematic approach; sanitary and hygienic control.

ISSN 2313-478X (print), ISSN 2411-3921 (online)

Introduction

Ensuring the safety and quality of food products is an essential component of the national food security system and a necessary condition for preserving public health. The intensification of production, the introduction of advanced food technologies, the use of food additives, the globalization of food markets, and the expansion of international trade significantly broaden the system of food safety assurance. Additional risk factors include environmental pollution, the use of agrochemicals and veterinary drugs in agriculture, the increasing duration and complexity of supply chains, as well as imperfections in production control systems at certain stages of the technological process. These factors necessitate the improvement of food safety control and supervision systems in line with modern scientific, technical, and regulatory requirements.

Under current conditions, food safety control is transforming from a predominantly inspection-based model into a comprehensive risk management system covering all stages of the supply chain: from raw material sourcing to the delivery of the final product to consumers. The harmonization of national legislation with European Union standards предусматривает the implementation of integrated state control systems based on risk assessment and traceability principles, enabling rapid response to potential hazards and minimizing risks to consumer health.

Literary review

Control of food safety and quality during production involves the application of a set of interrelated approaches aimed at minimizing risks, ensuring compliance with established standards, and enhancing the competitiveness of food industry enterprises. Modern scientific literature pays considerable attention to specific methods of product safety control, including microbiological, chemical, sanitary-hygienic, and technological control, as well as the implementation of food safety management systems based on risk analysis.

In the context of food chain traceability, research [1] has systematized the importance of information systems for managing product safety and quality. Full traceability of raw materials and finished products – from supplier to end consumer – facilitates the rapid identification of hazard sources and reduces response times in critical situations. The authors of study [2] analysed the impact of Industry 4.0 technologies on food safety management, demonstrating that digital systems enhance traceability and ensure a swift response to critical events. Furthermore, study [3] examined sources of contamination, modern risks, and detection technologies, confirming the significance of information and analytical systems for safety management at all levels of the food chain.

Raw materials are a critical object of control, as their quality largely determines the characteristics of the final product. The authors of [4] assessed the risks of pathogenic microorganisms entering food products and demonstrated the need to combine laboratory testing, monitoring of critical control points, and integrated safety management systems. In [5], the authors investigated mycotoxin contamination in Asian countries, confirming the global relevance of microbiological hazard control. Identifying mycotoxins is essential at all stages of production. The authors of [6, 7] emphasized the effectiveness of machine learning algorithms for early mycotoxin detection and explored the use of RFID and IoT technologies to monitor contamination in the food chain, which enhances the speed of response to potentially hazardous situations.

The impact of chemical contaminants on food safety, along with methods for their control and reduction of harmful substances, has been analysed. In particular, the authors [8] investigated the sources of chemical contamination during technological processing and emphasized the need for systematic monitoring at all stages of the production process. In [9], the authors investigated the chemical, biological and toxicological risks associated with food products, using the example of fish products, emphasizing the importance of comprehensive control at all stages of production. Packaging also serves as a vital element of quality assurance. In [10], the authors investigated the application of smart packaging with biodegradable freshness indicators, which increases production transparency and provides consumers with real-time information about the freshness of the product.

In study [11], the fundamental principles of safe food production at various stages of the technological process were analysed, methodological foundations for implementing safety standards in industrial conditions were proposed, and the importance of a systemic approach to safety management was emphasized. The authors of [12, 13] presented the results of an analysis of modern concepts in food quality and safety management, comparing traditional and modern approaches. They highlighted international experience and identified key efficiency factors for safety management systems and their impact on enterprise competitiveness. In publication [14], the authors assessed the economic and organizational benefits of implementing the HACCP system and demonstrated its impact on reducing product contamination risks. The studies provide practical examples of applying HACCP principles and underscore their vital role as a strategic tool for quality and safety management.

In the study [15], an overview of food quality audit and control practices in the European Union and worldwide was conducted. The methods for evaluating the effectiveness of internal and external audits were systematized, international standards and regulatory requirements were examined, and trends in the automation and digitalization of quality control were highlighted.

Thus, modern food safety management systems combine comprehensive control of chemical and microbiological risks, integrated HACCP and ISO standards, advanced monitoring technologies, and digital information systems to ensure traceability, rapid response, and stable product quality. This approach strengthens consumer confidence in products and serves as a vital element of a balanced quality management system.

Despite a significant number of scientific studies dedicated to ensuring food safety and quality, several aspects of this issue remain insufficiently systematized. At the same time, existing research primarily examines these types of control in isolation or within specific technological processes and food industry sectors. Issues

regarding their comprehensive systematization in the context of industrial food production remain underdeveloped, particularly concerning the determination of interconnections between different types of control and their role in forming an effective safety and quality management system.

Furthermore, the integration of diverse control modalities into a unified safety and quality assurance system across all production stages – from raw material procurement to the final product release – necessitates further scientific substantiation. Addressing these issues is vital for enhancing the efficacy of production control, mitigating hazardous risks, and ensuring the consistent quality and competitiveness of food products.

Formulation of the problem

The purpose of the study is to systematize the types of food safety and quality control during industrial production, as well as to substantiate their role in ensuring effective risk management, maintaining appropriate safety and quality levels, and enhancing the competitiveness of food industry enterprises

Research objectives:

to analyse modern approaches to food safety and quality control in industrial production;

to classify control types by risk type (physical, chemical, biological) and production stages;

to systematize the main tools of food safety control at food industry enterprises;

to substantiate the role of integrated control in ensuring effective risk management and increasing enterprise competitiveness.

Materials and methods

The theoretical and methodological framework of the study is based on the research of domestic and foreign scholars concerning food safety and quality assurance, risk management in the food industry, as well as international and national regulatory documents in the field of food safety.

A complex of general scientific and specialized methods of scientific cognition was employed during the research. In particular, a comprehensive review and consolidation of current research were conducted to explore evolving paradigms in food safety and quality management. The systematization method was used to classify types of control according to the nature of risks and stages of the production process. The comparative analysis method allowed for identifying the specific features of various approaches to organizing product safety control in the food industry.

A systems approach was applied to develop a generalized structure for food safety and quality control at food industry enterprises, incorporating interconnected control elements across different production stages. This approach enabled the determination of the role of integrated control in ensuring effective risk management and maintaining the appropriate levels of food safety and quality.

Results of the study and their discussion

Food safety control is based on a preventive approach that involves systemic management of potential hazards at all stages of the production process. This approach is aimed at early risk identification and prevention before they can affect product quality or safety. It relies on an integrated combination of technological control, laboratory analysis, food safety management systems, and modern digital technologies for monitoring production processes. The control system also incorporates statistical risk assessment methods, trend analysis, and forecasting of potential issues, enabling the planning of preventive measures and the optimization of corporate resources.

One of the most widespread and effective tools for ensuring food safety in industrial production is the Hazard Analysis and Critical Control Points (HACCP) system. This system provides for the systematic identification of potential biological, chemical, and physical hazards that may arise during the production, processing, storage, and transportation of products. Based on the analysis performed, critical control points are determined, within which continuous monitoring of technological parameters is carried out and measures are implemented to prevent or minimize hazardous factors. The main feature of this approach is its preventive nature in risk management. The primary focus is on preventing the occurrence of hazards, whereas techno-chemical quality control of products and semi-finished goods detects the presence or absence of hazardous compounds in the material flow or finished product. The HACCP system entails maintaining detailed documentation, ensuring process transparency, auditability, and the traceability of any deviations from established standards.

Further development of food safety management systems is associated with the integration of HACCP principles with international food safety management standards developed and implemented by various foreign countries, including standards such as Dutch HACCP, IFS Food, BRC Food, BRC IoP, GLOBALG.A.P., and FSSC. Such integration forms a comprehensive food safety management system that combines HACCP principles, prerequisite programs (PRPs), and systemic management mechanisms. This ensures more effective organization of production control, clear delineation of functions and responsibilities among process participants, and increased transparency and controllability of production procedures. The implementation of international standards contributes to the harmonization of food safety requirements in both domestic and international markets, which is particularly important for enterprises planning to export products or cooperate with global suppliers.

An important direction in the development of control systems is the implementation of traceability systems. These systems make it possible to track the movement of raw materials, ingredients, and finished products at all stages of the production and supply chain – from raw material sourcing to delivery to the final consumer. Traceability systems enable rapid identification of the source of potential hazards, localization of problems, and timely withdrawal of unsafe products from circulation. They also enhance the transparency of production processes, facilitate supplier audits, and support the development of consumer trust. When combined with digital platforms and analytical tools, such systems enable risk forecasting and optimization of logistics processes, thereby reducing economic losses for enterprises in the

ISSN 2313-478X (print), ISSN 2411-3921 (online)

event of product-related issues.

A significant role in improving the efficiency of food safety control is played by the use of modern digital technologies. These include automated systems for monitoring temperature regimes, sensor-based systems for controlling humidity and other environmental parameters, Internet of Things (IoT) technologies, artificial intelligence platforms for analyzing large datasets, and blockchain platforms for recording and verifying information on product movement within the food chain. The use of such tools allows continuous real-time monitoring of critical parameters, ensures increased accuracy of control, enables prompt response to deviations of technological indicators from the established process parameter ranges, and reduces the likelihood of errors associated with the human factor.

Modern approaches to food safety and quality control involve the application of integrated international standards and industry certification systems that coordinate the activities of producers, suppliers, and regulatory bodies within the global food chain. These standards ensure the harmonization of product safety requirements, streamline audit procedures, and enhance the effectiveness of risk management and compliance with international regulatory requirements.

The classification of control types according to the nature of potential hazards and the stages of the production process is an important tool for effective product safety management. It allows for a systematic assessment of risks, identification of critical control points, and timely detection of hazardous factors that may arise during the production, storage, or distribution of food products. The main types of hazards are divided into biological, chemical, and physical.

Biological risks are associated with the presence of pathogenic microorganisms, bacteria, viruses, parasites, or their metabolic products, including toxins, in food products. The most common biological hazards include bacteria of the genera *Salmonella*, *Listeria*, *Escherichia coli*, as well as microscopic fungi that produce mycotoxins. Control of biological risks is carried out through microbiological testing of raw materials, semi-finished and finished products, monitoring of sanitary and hygienic conditions of production facilities, and ensuring compliance with temperature regimes during storage and processing.

Chemical risks are associated with the possible contamination of food products by hazardous chemical substances, such as pesticide residues, veterinary drugs, heavy metals, toxic elements, residues of cleaning and disinfecting agents, or food additives in concentrations exceeding permissible limits. Control of chemical risks includes laboratory analyses using chromatography, spectrometry, and other modern analytical methods for raw material testing, with results reflected in certificates of conformity confirming compliance with state standards, as well as monitoring of technological parameters of the production process.

Physical risks are related to the presence of foreign objects in food products that may pose a danger to consumers. These include metal fragments, glass, stones, plastic, packaging materials, or equipment parts. Control of physical hazards is ensured through the use of metal detectors, X-ray scanners, sieving and filtration systems, as well as regular technical inspection of equipment.

The division of control by stages of the production process allows for the organization of comprehensive monitoring of product safety and quality. At the stage of incoming control, the quality and safety of raw materials, ingredients, and auxiliary materials supplied by vendors are verified. This includes supplier audits, laboratory testing of raw materials, and assessment of their compliance with established standards and technical specifications. Incoming raw materials and packaging are checked based on certificates of conformity at the procurement and acceptance stages.

Process control is carried out directly during production and includes monitoring of technological parameters such as temperature, humidity, pressure, processing time, and other factors affecting product safety and quality. This helps prevent contamination, growth of hazardous microorganisms, formation of toxic substances, and the emergence of other risks.

Finished product control involves assessing compliance with established safety and quality indicators through physicochemical, microbiological, and organoleptic testing. Sanitary and hygienic control of the production environment ensures cleanliness of facilities, equipment, and tools, as well as compliance with personal hygiene rules by personnel, which is a key factor in preventing microbiological contamination.

The combination of different types of control and their integration into a unified risk management system ensures the continuity of the safety management process, timely identification of potential hazards, stable product quality, and increased consumer trust. A systemic approach to control organization involves the integration of incoming raw material control, in-process technological control, sanitary and hygienic monitoring of the production environment, and finished product inspection. Such integration ensures continuity in food safety management and enables timely detection of deviations from established standards.

Within the production control system, it is important to consider the interrelationship between types of risks and stages of the technological process. Biological, chemical, and physical hazards may arise at different stages of production; therefore, their control must be carried out comprehensively, taking into account the specifics of technological operations.

To summarize these approaches, it is advisable to systematize the types of food safety and quality control according to risk categories and stages of the production process (Table 1). This approach enables food industry enterprises to minimize risks, comply with international standards, and strengthen their competitiveness in both domestic and international markets.

Conclusion

Ensuring the safety and quality of food products in the current conditions of the food industry development requires the implementation of comprehensive and systematically organized control mechanisms. The study analyzes modern approaches to controlling food safety and quality in industrial production, which made it possible to establish their key role in preventing the occur-

Table 1 – Systematization of Types of Food Safety and Quality Control in the Production Process

Risk Type	Production Stage	Main Types of Control	Control Methods
Biological	Incoming raw material control	Verification of certificates of conformity regarding safety indicators in accordance with regulatory documents (DSTU, technical specifications, or additional contract requirements)	Analysis for pathogenic microorganisms and mycotoxins
	Technological process	Sanitary and hygienic control, operational control of technological parameters, technological control of physicochemical parameters of material flows	Monitoring of temperature regimes, sanitary monitoring
	Finished product	Microbiological control, control of physicochemical parameters of the finished product	Laboratory testing, compliance control with regulatory documents
Chemical	Incoming raw material control	Verification of certificates of conformity regarding safety indicators in accordance with regulatory documents (DSTU, technical specifications, or additional contract requirements)	Analysis for pesticides, heavy metals, toxic elements
	Technological process	Operational control of technological parameters, technological control of physicochemical parameters of material flows	Monitoring of additive use, control of technological parameters
	Finished product	Physicochemical control of the finished product	Chromatographic and spectrometric methods, compliance control with regulatory documents
Physical	Incoming raw material control and technological process	Visual inspection and technical control	Metal detectors, filtration systems
	Technological process	Technical control of equipment condition and engineering systems, condition of surfaces in production facilities, protective barriers against foreign object contamination	Periodic maintenance and preventive inspection
	Packaging	Control of packaging materials	Visual inspection, X-ray scanning

rence of hazardous factors and maintaining stable product quality indicators.

The classification of control types by risk categories (physical, chemical, and biological) and by stages of the production process has shown that effective food safety management is only possible through the integration of various forms of control covering all stages of production—from raw material inspection and monitoring of technological parameters to the evaluation of finished product quality indicators. Such classification enables a systematic approach to hazard identification, risk assessment, and the determination of appropriate control measures. The application of a systemic approach to food safety and quality control contributes to improving the efficiency of production risk management, optimizing technological processes, and ensuring the stability of product quality indicators. The integration of various control tools into a unified management system allows for the timely identification of potential hazards, minimization of the negative impact of hazardous factors, and enhancement of the reliability of production processes.

The implementation of a systemic approach to food safety and quality control is of great importance for ensuring product compliance with international requirements and standards, increasing the level of consumer health protection, and strengthening the competitiveness of food industry enterprises. In the context of achieving the Sustainable Development Goals, this contributes to the formation of safer, more efficient, and more sustainable food production systems.

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УДК 664:658.562:614.31

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СИСТЕМНІ ПІДХОДИ ДО КОНТРОЛЮ БЕЗПЕЧНОСТІ ТА ЯКОСТІ ХАРЧОВИХ ПРОДУКТІВ

Анотація

У забезпеченні безпечності та якості харчових продуктів важливу роль відіграє системний підхід до організації контролю на всіх етапах виробництва. Сучасний розвиток харчової промисловості, розширення глобальних ланцюгів постачання, зростання вимог споживачів до якості продукції та посилення міжнародних стандартів безпечності зумовлюють необхідність удосконалення підходів до управління ризиками у промисловому виробництві харчових продуктів. Забезпечення належного рівня безпечності продукції передбачає контроль якості готового продукту та системне управління потенційними небезпеками на всіх стадіях виробничого процесу: від постачання сировини до реалізації готової продукції. Розглянуто сучасні підходи до організації контролю безпечності та якості харчових продуктів у промисловому виробництві. Особливу увагу приділено системному підходу до класифікації видів контролю відповідно до характеру можливих небезпек та етапів виробничого процесу. Проаналізовано основні категорії ризиків, що можуть виникати під час виробництва харчових продуктів, зокрема біологічні, хімічні та фізичні небезпеки, а також визначено особливості їх контролю в межах технологічних процесів підприємств харчової промисловості. Дослідження спрямоване на систематизацію видів контролю безпечності та якості харчових продуктів у промисловому виробництві та визначення їхньої ролі у формуванні ефективної системи управління ризиками. Розглянуто особливості організації вхідного контролю сировини, технологічного контролю під час виробництва, контролю готової продукції та санітарно-гігієнічного контролю виробничого середовища. Встановлено, що поєднання різних видів контролю та їх інтеграція у систему управління безпечністю харчових продуктів сприяє підвищенню ефективності виробничого процесу, мінімізації ризиків виникнення небезпечних факторів та забезпеченню стабільної якості продукції. Впровадження системного підходу щодо контролю безпечності та якості харчових продуктів забезпечує комплексне управління ризиками, підвищує рівень довіри споживачів до продукції та сприяє підвищенню конкурентоспроможності підприємств харчової промисловості на внутрішньому та міжнародному ринках. Використання інтегрованих систем управління безпечністю харчових продуктів, впровадження сучасних технологій моніторингу виробничих процесів та удосконалення процедур контролю створюють передумови для підвищення ефективності функціонування підприємств і забезпечення сталого розвитку харчової промисловості.

Ключові слова: управління безпечністю; безпечність харчових продуктів; НАССР; системний підхід; санітарно-гігієнічний контроль.

Received 08.01.2026 Revised 21.02.2026
Reviewed 17.01.2026 Approved 03.03.2026 Availlabe in Int. 10.04.2026

Cite as Vancouver Citation Style
Romanovska T. (2026), Systematic approaches to food safety and quality control. Grain Products and Mixed Fodder's, 26 (1, 101): 4-9. DOI https://doi.org/10.15673/gpmf.v26i1.3392

Cite as State Standard of Ukraine 8302:2015
Systematic approaches to food safety and quality control. / Romanovska T. // Grain Products and Mixed Fodder's. 2026. Vol. 26, Issue 1 (101). P. 4-9. DOI https://doi.org/10.15673/gpmf.v26i1.3392