

REVIEWS

INTEGRATED FOOD SAFETY CONTROL FOR EGGS USING THE ONE HEALTH APPROACH

Dragomir Ivanov¹, Antoaneta Stoyanova², Maria Pavlova³, Spasena Ilieva⁴,
Tsonko Paunov^{5,6}

¹*PhD student, Faculty of Public Health, Medical University of Varna, Bulgaria*

²*Department of Commodity Knowledge, Faculty of Economics,
University of Economics–Varna, Bulgaria*

³*National Center for Parasitic and Infectious Diseases, Sofia, Bulgaria*

⁴*Lozenets University Hospital, Sofia, Bulgaria*

⁵*Department of Hygiene and Epidemiology, Faculty of Public Health,
Medical University of Varna, Bulgaria*

⁶*Regional Health Inspectorate, Varna, Bulgaria*

ABSTRACT

Increasing food safety and ensuring the health and lives of consumers is a strategy related to the behavior of all participants in the food chain, from governmental and non-governmental institutions to food producers and traders to the final target groups of consumers. Eggs as food are consumed by a large target group of consumers and are present in daily nutrition. Issues related to ensuring the safety of eggs used for food production are constantly complicated by the constant dynamics of regulatory requirements and require the implementation of the interdisciplinary One Health approach to prevent the occurrence of food infections and epidemic outbreaks when safety is violated.

The purpose of this report is to review and analyze the main issues related to the theory, practice, and applicability of principles and approaches set out in the current regulatory mechanisms and requirements for achieving compliance with food safety policies.

In accordance with the set goal, the study used a systematic approach, inextricably linked to systemic analysis and synthesis. In identifying the main elements within the scope of modern food safety requirements, the expert approach was applied.

The results derived can be useful in formulating possible solutions for practice, as well as proposals for updating the requirements.

Keywords: food, disinfection, eggs, food safety, food chain, zoonoses, food- and waterborne infections

Address for correspondence:

Dragomir Ivanov
Faculty of Public Health
Medical University of Varna
55 Marin Drinov St
9002 Varna, Bulgaria
e-mail: drago.ivanov@icloud.com

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INTRODUCTION

In the last few decades, there have been fundamental changes in the regulatory framework focused on the food quality and safety requirements. This trend is particularly strong in the countries of the European Union (EU) and the European Economic Area. The requirements for producers and processors, as the main participants in the agri-food chain,



are increasing and new limitations and restrictions are being imposed on the one hand, and on the other hand, these changes in the regulatory framework create certain opportunities for passing or transferring responsibility for possible food incidents to consumers. The methods, technology, and intensification of livestock farming, as well as the introduction of a more restrictive policy regarding immunoprophylaxis and therapy of certain infectious diseases (including zoonoses) among populations of certain productive animals, also impose higher requirements on producers and control bodies.

When we consider the countries of the former socialist camp and specifically Bulgaria, we can identify a serious change in the organization, production, treatment and preventive activities, and a serious shift in the focus of the control bodies, Bulgarian Food Safety Agency (BFSa) and regional health inspectorates (RHIs), towards identification, quality control, precision in regard to the movement of herds and populations, and food and water quality control. With this changed focus from broad treatment and preventive activities to a control and regulatory function, there is a large reliance on conscientious compliance with the legislation by the other participants in the agri-food chain. However, for this purpose, even more strengthened and integrative communication between the countries is necessary, which is the main goal of the One Health (OH) concept.

The sources of foodborne infection are due to a specific manifestation of a certain factor as a result of which a specific incident occurs based on the increased concentration of a given risk factor or hazard. All biological or chemical factors, toxins or microorganisms, can be considered as such. These factors, which are not intentionally added to the product, are considered as contaminants and are subject to control, for which the relevant requirements are introduced (1).

There are serious changes in the requirements of institutions for the control and management of diseases arising from the consumption of unsafe foods. All this necessitates the adoption of radically different approaches to the creation and implementation of quality and safety management strategies. The new management strategy requires moving to-

wards management changes oriented towards the creation of a sustainable systems (2).

The safety of food and raw materials in the food chain has had a different understanding, meaning and impact on the population in Bulgaria in recent years. The institutions and bodies responsible for implementing this control are different and are undergoing a number of structural changes to comply with modern regulations. The new goal of these bodies is to control and monitor the chain in our modern world. With the development of technology, globalization, and the unhindered connectivity of different regions, we increasingly need to strengthen the focus on human health and understand it as closely related to the health of plants, animals, the state of the environment and ecosystems, as well as to the access to quality and safe food and water (3).

AIM

The purpose of this report is to conduct a thorough and practice-oriented review of the current regulatory mechanisms and practical solutions for consumer safety control in regard to egg processing procedures. In addition, the article aims to study and analyze the available solutions worldwide. Substantiated proposals to the countries involved in the legislative process will be made in order to achieve compliance with the adopted food safety policies on the one hand, and on the other hand to clear up the existing practical paradoxes for producers and service providers, all in the name of consumer safety.

Achieving the set goal will clarify the entire process for all participants in the production, processing, and use of eggs and egg products, as well as for service providers using raw materials.

To achieve this goal, we set the following tasks:

- ◆ To conduct a retrospective analysis of the level, method, and responsibility for the control of food and raw materials along the food chain, and, in particular, eggs as the main raw material used in food products.
- ◆ To analyze and take into account the strengths and weaknesses of the current interaction and communication between human and veterinary institutions in both food control and the control of zoonoses, and the use of antibiotics, which ultimately has a bearing on antimicrobial resistance (AMR).

MATERIALS AND METHODS

The current scientific study represents a highly practice-oriented part of a larger scientific project, which is in the field of prevention and control of infections in society through the OH) holistic interdisciplinary approach. The latter has received an approval with Protocol No. 128 of 02.03.2023 from the Research Ethics Committee at the Medical University of Varna.

In accordance with the set goal, the study used a systematic analytical approach, inextricably linked to systematic analysis and synthesis. When identifying the main elements within the scope of modern food safety requirements, the expert approach was applied. An interdisciplinary team was formed, uniting specialists from different fields, allowing for an integrative result and a holistic view of the processes.

A full analysis of specialized Bulgarian and foreign scientific publications, EU regulations, as well as recommendations from leading manufacturers of biocidal products and disinfection products was carried out, applying the empirical experience and knowledge of each member of the scientific team.

RESULTS AND DISCUSSION

Codex Alimentarius, CAC/RCP 15-1976, establishes rules known as the Code of Hygienic Practice for Eggs and Egg Products. It defines terms relating to contamination of eggs, and defines a contaminated egg as an egg with foreign matter on the surface of the shell, including egg yolk, manure, or soil. Microbicidal treatment is a control measure that eliminates the range of microorganisms, including pathogenic microorganisms, present in a food, or reduces them to a level where they do not pose a health hazard (4).

There are diseases that are of global importance and international trade could be severely affected by food safety and quality requirements. In 2005, according to an opinion on microbiological risks in the washing process of eggs for consumption, adopted on 7 September 2005 by the Scientific Committee on Biological Hazards of the European Food Safety Authority at the request of the Commission, the practice of washing and disinfection of eggs was introduced, aimed at supporting the assurance of safety through the implementation of hygiene practices set out in the legislation (5).

According to Regulation 2023/2465, 2023, the standards related to the trade of eggs have been defined. They indicate that eggs should not be washed or cleaned, because such practice can cause damage to the shell or increase its permeability and the shell itself, which with its antimicrobial properties represents an effective barrier against the penetration of bacteria and the corresponding contamination of the egg (1). According to Møller and colleagues, 70% of foodborne illnesses in the world are related to food prepared in restaurants (6).

Salmonella spp. is the causative agent of salmonellosis, which is the second most commonly reported gastrointestinal infection in the EU. The European Food Safety Authority reports that, after the domestic environment, the most common sites of infection transmission are catering establishments. The most frequently reported sources of infection are eggs and/or foods containing eggs, followed by products such as meat and vegetables. Epidemiological and microbiological studies have shown the potential to identify and subsequently analyze the common risk factors identified, including the occurrence of cross-contamination between heat-treated foods and raw materials or inadequately cleaned food contact surfaces (7).

International outbreaks of *Salmonella spp.* are recorded annually in the EU, often originating from chicken eggs and/or poultry meat imported or produced in the EU. The logistics of eggs, contamination of eggshells with the pathogen, storage and preparation of food for a household or a large group of people are risk factors for causing salmonella enterocolitis worldwide. The risk groups are young children, the elderly, and people with immunodeficiency. Often, the salmonella serotypes causing outbreaks exhibit antimicrobial resistance, which is directly related to the use of antimicrobials in agriculture. This is a risk factor for global health. Reducing the possibility of contamination of chicken eggs with *Salmonella spp.* and other pathogens will improve the quality of prevention and prophylaxis of food- and waterborne infections and limit the spread of resistant bacteria.

Each country, through its regulatory and control institutions, introduces regulatory requirements for each participant in the food chain, obliging them to develop and implement systems for managing

and ensuring food safety (8). The safety of food offered on the market is responsibility of the producers, food traders, and service providers. All regulatory and legislative institutions work towards ensuring effective mechanisms through the development of requirements to protect the health of the population of their country (2).

The fundamental regulatory group is the so-called Hygiene Package, which sets the requirements for food producers and traders, as well as service providers in the industry, to develop and implement Food Safety Management Systems (FSMS) in their practices. The scope of the FSMS, as elements, includes the development of objectives, policy with the implementation of Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP). Good Hygiene Practices are mandatory for implementation by every branch of the food industry. Each food production facility must be designed and built in accordance with the requirements set out in Regulation (EC) No. 852/2004 on the hygiene of foodstuffs of the European Parliament and the European Council from 29 April 2004 (9).

Hygiene practices are general rules for the entire sector and introduce cleaning and disinfection procedures. These are the minimum required procedures and activities that ensure product safety. Effective cleaning and disinfection of production and commercial premises, their associated equipment, tableware, and eggs are the main factors that determine the quality and safety of food products and ensure the interruption of the transmission mechanism of potential causes of food infections or intoxications. Egg disinfection should achieve a reduction in microbial contamination and reduce the risks related to the safety of eggs and egg products. However, different countries have different requirements and in a number of them washing and disinfection of eggs is prohibited. Washing eggs is a key point in interrupting the transmission mechanism and generating a high hygiene risk.

For cleaning and disinfection in food production, processing and distribution facilities, only preparations authorized for sale under the requirements of Regulation (EU) No 528/2012 (10), Regulation 648/2004 (11) are used, or under the Act on Protection from the Harmful Effects of Chemical Sub-

stances and Mixtures, subject to compliance with the conditions of the issued permit and the requirements specified on the label. Chemicals with altered quality, expired shelf life, and damaged packaging are not used (12).

As our previous unpublished data have shown, informal egg treatment practices are being implemented in catering establishments before they are used in food or offered directly to the consumer. This is done following informal recommendations and residual data from previous experience, despite the existing ban on treating or washing eggs before use.

When reviewing all recommended preparations by the various participants in the process—controllers or manufacturers, including preparation dealers, it was found that there was no indication or possibility for treating eggs, which is normal in view of the Regulation introduced in 2023, which allows the disinfection of eggs to be carried out only for those used for hatching (13). In this case, the biocidal products belong to the PT3 group. Upon further investigation of the marketing licenses for biocidal products that were presented as approved for this, it was confirmed that the use on eggs was not included in the authorization, which is normal under the current Regulation 2023/1454 of 13 July 2023. The recommended preparations with active substances (hydrogen peroxide alone or in combination with inactive silver ions, in the form of mist, cold or warm aerosol) also showed inconsistency with the possibility of treating eggs for human consumption, although the preparations themselves are actively recommended for this.

In view of the above facts and the current situation, service providers that include the supply of food containing eggs are faced with the challenge of not being able to meet both the requirements of the legal provisions regarding the prohibition of egg treatment and the interruption of the potential cross-contamination mechanism. This turns out to be a serious normative paradox, which has its practical expression and creates risks.

A review of the literature on the global experience shows the following:

According to the studies of Davies & Breslin, 2003, the conventional disinfection technology for cleaning and reducing microbial activity on the surface of the egg is based on chlorine and has many

disadvantages, such as the formation of carcinogenic compounds or a decrease in its effectiveness due to the presence of organic matter (14).

Some authors have conducted studies that prove the effectiveness of certain active substances, as in the case of teotropin, a quaternary ammonium compound. They have a pronounced bacteriostatic effect on epizootically significant bacteria and fungi (15). Other authors prove that the optimal variant in the composition of the teotropin-based disinfectant mixture can be used as a new disinfectant in facilities where sanitary control is carried out (16).

Marc et al. demonstrate that the cost-effectiveness of disinfection is defined as the optimal point at which the additional cost of reducing pathogen spread has minimal effects on reducing food risk (17).

Disinfection of eggs by treatment with plasma-activated aqueous solutions of hydrogen peroxide can reduce microbial contamination on the surface of eggs (18).

According to some experts, it is standard practice in the United States to wash and disinfect eggs before packing or breaking. Chlorine is the most common Active ingredient, but peracetic acid, quaternary ammonium compounds (QAC), and ultraviolet light are also used as pre-consumption methods. Despite the wide variety of active ingredients and biocide formulations, there is still no “green” formulation or one that is non-toxic to eggs and, consequently, consumers.

Daniela Bermudez-Aguirre and team reviewed the methods that are alternatives to thermal pasteurization of eggs for cooking, namely: thermal techniques, such as using radiofrequencies, microwaves, ohmic heating (electricity through the egg); non-thermal techniques, such as light irradiation, cold plasma, ozone, irradiation, high-pressure carbon dioxide; natural and chemical antimicrobial agents, such as essential oils, peptides, herbal extracts, organic acids, enzymes, bacteriocins and bioactive compounds such as phenols; ultrasonic techniques, etc. Their results show that the correct pasteurization process can reduce the risk of salmonella in eggs, which also preserves their functional properties. The new technologies studied are recognized as options to conventional thermal processing without changing the quality or nutritional content. In addition, these technolo-

gies can disinfect the eggshell and reduce the number of microorganisms on the egg surface. However, according to their study, the best alternative for egg pasteurization would be a combination of two or more technologies to achieve shell disinfection and consumer safety. According to their study, these new technologies are environmentally friendly, but they need to be validated for further mass use (19).

CONCLUSION

There is a regulatory implementation paradox and a gap in ensuring maximum safety for consumers of chicken eggs. On the one hand, reliable data are available on the harmful effects of certain chemical agents used in the treatment of eggs and the potential risks for consumers, and on the other hand, alternative methods have not yet been proven and studied well enough to be introduced. The introduced regulation prohibits the treatment of eggs before their use and the service providers themselves are forced apply other methods that aim to reduce the risks and food infections due to contaminated eggs in the network.

Traceability throughout the food chain and the development of effective hygiene measures and policies in each of the sectors part of the agri-food chain contribute to the process of ensuring consumer safety. It is the responsibility of the experts in the chain to thoroughly analyze the available practical options for the treatment and prevention of foodborne infections related to the consumption of eggs and review the current legislation for inapplicable and self-excluding texts. It is important for professionals to work towards the introduction of a safe method of prevention, which is at the same time effective, easy to implement, and cost-effective.

Taking into account the above, we can note that it is of paramount importance to improve the communication process, apply an interdisciplinary approach in the study and analysis of these infections, and develop a coordination mechanism using both the principles of the EU and a holistic approach.

REFERENCES

1. Delegated regulation - EU - 2023/2465 - EN - EUR-Lex [Internet]. Europa.eu. 2023. Available from: http://data.europa.eu/eli/reg_del/2023/2465/oj

2. Stoyanova A. Modern approaches to food safety management. Varna: Science and Economics;2020. (in Bulgarian).
3. FAO, UNEP, WHO, WOA. One Health Joint Plan of Action, 2022–2026. FAO; UNEP; WHO; World Organisation for Animal Health (WOAH) (founded as OIE); 2022.
4. Codex Alimentarius. 1997. Code of Hygienic Practice for Eggs and Egg Products. CAC/RCP 15-1976. Rome: Codex Alimentarius Joint Office.
5. Opinion of the Scientific Panel on biological hazards (BIOHAZ) related to the Microbiological risks on washing of Table Eggs. EFSA Journal. 2005 Oct;3(10):269
6. Møller CO, Nauta MJ, Schaffner DW, Dalgaard P, Christensen BB, Hansen TB. Risk assessment of Salmonella in Danish meatballs produced in the catering sector. *Int J Food Microbiol*. 2015 Mar 2;196:109-25. doi: 10.1016/j.ijfoodmicro.2014.10.010.
7. Tóth A, Kovács A, Törőné Dunay A, Illés BC, Bittsánszky A. Traceability and cross-contamination–Food safety knowledge of Hungarian foodservice workers. In: *Proceedings of the International Conference on Management: “People, Planet and Profit: Sustainable business and society*. Vol. 1;2019. pp. 374-382.
8. Food Law, 2020 [Internet]. Available from: <https://lex.bg/bg/laws/ldoc/2137203080>. (in Bulgarian).
9. EUR-Lex - 32004R0852 - EN - EUR-Lex [Internet]. [eur-lex.europa.eu](https://eur-lex.europa.eu/eli/reg/2004/852/oj/eng). Available from: <https://eur-lex.europa.eu/eli/reg/2004/852/oj/eng>
10. Regulation - 528/2012 - EN - EUR-Lex [Internet]. [Europa.eu](https://eur-lex.europa.eu/eli/reg/2012/528/oj/eng). 2024. Available from: <https://eur-lex.europa.eu/eli/reg/2012/528/oj/eng>
11. Regulation - 648/2004 - EN - EUR-Lex [Internet]. [Europa.eu](https://eur-lex.europa.eu/eli/reg/2004/648/oj/eng). 2015. Available from: <https://eur-lex.europa.eu/eli/reg/2004/648/oj/eng>
12. Act on the protection from the harmful impact of chemical substances and mixtures [Internet]. [Government.bg](https://www.moew.government.bg/en/act-on-the-protection-from-the-harmful-impact-of-chemical-substances-and-mixtures/). Available from: <https://www.moew.government.bg/en/act-on-the-protection-from-the-harmful-impact-of-chemical-substances-and-mixtures/>
13. Implementing regulation - 2023/1454 - EN - EUR-Lex [Internet]. [Europa.eu](https://eur-lex.europa.eu/eli/reg_impl/2023/1454/oj/eng). 2023. Available from: https://eur-lex.europa.eu/eli/reg_impl/2023/1454/oj/eng
14. Davies RH, Breslin M. Investigations into possible alternative decontamination methods for Salmonella enteritidis on the surface of table eggs. *J Vet Med B Infect Dis Vet Public Health*. 2003 Feb;50(1):38-41. doi: 10.1046/j.1439-0450.2003.00622.x.
15. Voyno L, Khramtsov MA, Suvorov OA. Influence of disinfectants of different chemical composition on reduction of microbial contamination of chicken eggs. *Food Ind*. 2017;(2):55-57.
16. Borisevich AS, Vysotsky AE, Lysenko AP. The effect of disinfectant compositions based on teo-tropin on epizootically significant microorganisms. *Epizootol Immunobiol Pharmacol Sanitation*. 2023;(2):44-52.
17. Marc RA, Crina CM, Postolache AN, Crivei IC, Veleşcu ID. Advanced Risk and Hazard Analysis in the Egg Sorting-Packing Station Industry from Supplier Selection to Delivery in Chain Stores under GFSI Integrated Food Safety Programs [Internet]. 2024. Available from: https://www.researchgate.net/publication/377224954_Advanced_Risk_and_Hazard_Analysis_in_the_Egg_Sorting-Packing_Station_Industry_from_Supplier_Selection_to_Delivery_in_Chain_Stores_under_GFSI_Integrated_Food_Safety_Programs
18. Pivovarov O, Kovalova O, Koshulko V. Disinfection of marketable eggs by plasma-chemically activated aqueous solutions. *Food Sci Technol*. 2022;16(1):101-11.
19. Bermudez-Aguirre D, Niemira BA. A review on egg pasteurization and disinfection: Traditional and novel processing technologies. *Compr Rev Food Sci Food Saf*. 2023 Mar;22(2):756-784. doi: 10.1111/1541-4337.13088.