

Review Paper

BIOSECURITY MEASURES FOR PREVENTION AND CONTROL OF *SALMONELLA* IN POULTRY FARMS



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Simona Naumovska¹, Annamaria Galfi Vukomanović², Marko Pajić³, Slobodan Knežević³, Biljana Đurđević³, Bojana Blagojević^{2*}



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¹Veterinary Clinic "Aleksi-vet", Bistrica, Bitola, Republic of North Macedonia

²Department of Veterinary Medicine, Faculty of Agriculture, University of Novi Sad, Trg Dositeja Obradovića 8, 21 000 Novi Sad, Serbia

³Scientific Veterinary Institute "Novi Sad", Rumenacki put 20, 21000 Novi Sad, Serbia

*Corresponding author: bojana.vidovic@polj.uns.ac.rs

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ABSTRACT

Biosecurity measures in poultry farms are essential for maintaining animal health and welfare. Developing and implementing daily biosecurity protocols on farms reduce the entry of pathogenic microorganisms which can have direct impacts on the production processes. One of the most challenging zoonotic diseases to control in poultry flocks is salmonellosis. Poultry is considered an important reservoir of *Salmonella*, with poultry meat and eggs being the most common sources of salmonellosis infection in humans. *Salmonella* can be transmitted horizontally through contaminated environments and vertically from parent flocks to their offspring. Strict biosecurity protocols, together with effective immunoprophylactic measures, are an alternative for prevention and control of the disease. *Salmonella* is widespread globally and is particularly endemic in livestock farming regions. Its control strategies should address the entire chain, from meat production to storage, i.e. "from farm to table". This review paper aims to provide an overview of biosecurity implementation and evaluation in poultry farming worldwide, while also exploring potential barriers and reasons for its non-implementation.

Key words:

biosecurity measures, infection protection, zoonosis, poultry

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INTRODUCTION

An essential part of commercial poultry production is protection of the flock from ingress and contamination by unwanted microorganisms. *Salmonella* poses a significant global threat to the poultry industry, and salmonellosis is one of the major public health concerns worldwide (Tariq et al., 2022). Certain *Salmonella* species are highly pathogenic in chickens, while others induce a weaker response, resulting in asymptomatic carriers. These asymptomatic animals can persist in production flocks, potentially transmitting the zoonotic bacterium along the food chain. Globally, *Salmonella* is responsible for approximately 93 million cases of gastroenteritis and 155,000 deaths annually (Castro-Vargas et al., 2020). Despite significant progress in its control, there is an ongoing need for development of various prevention strategies.

Salmonella spp. belongs to the family *Enterobacteriaceae*, comprising over 2500 serovars causing salmonellosis. Morphologically, they are short, ovoid, facultatively anaerobic, gram-negative rods measuring 2-3 x 0.4-0.6 µm and

do not form spores. While most serovars are motile due to flagella, *S. gallinarum* and *S. pullorum* are stationary (Nwabor et al., 2015). All animals, including humans, can transmit *Salmonella*. Contaminated poultry eggs and meat products are the primary sources of *Salmonella* infections in humans, with serovars such as *S. typhimurium* and *S. enteritidis* being particularly problematic (Ehuwa et al., 2021). Consumption of raw or underprocessed contaminated poultry products can result in acute gastroenteritis, with symptoms typically appearing 12 to 72 hours after infection (Russell, 2012). Emerging serotypes, including *S. heidelberg*, *S. javiana*, *S. infantis*, and *S. thompson*, have been increasingly reported as causes of human infections in the United States (Castro-Vargas et al., 2020). The severity of disease manifestation can vary based on serotype, virulence factors, infectious dose, and host immunity, with immunocompromised individuals being particularly susceptible to severe symptoms, including sepsis (Russell, 2012). Additionally, the ongoing emergence of antimicrobial resistance among various *Salmonella* serovars raises further public health concerns (Maka and Popowska, 2016).

In response to these health concerns regarding salmonellosis and other pathogens in poultry, the European Union has established regulations requiring member states to implement research and control programs aimed at mitigating these threats, especially at the primary production level. While decontaminating final poultry products is a straightforward approach to controlling *Salmonella*, the use of carcass disinfectants is prohibited in the EU, and decontaminating fresh eggs remains challenging (Vandeplas et al., 2010).

Vectors such as rodents and cockroaches can also play a significant role in *Salmonella* transmission. Research has demonstrated that peridomestic rodents can serve as reservoirs for zoonotic foodborne pathogens, facilitating the spread of *Salmonella* in poultry environments (Jahan et al., 2021). These pests can introduce *Salmonella* into flocks by contaminating feed and water sources. Therefore, effective pest management strategies are crucial in mitigating this risk and preventing outbreaks.

While this manuscript provides a comprehensive overview of biosecurity measures, it also acknowledges the necessity for further research to elucidate the specific impacts of these measures on controlling salmonellosis in poultry. Future studies should focus on quantifying the effectiveness of individual biosecurity practices, such as controlling farm access, hygiene protocols and flock monitoring, in reducing the prevalence of *Salmonella*. By analyzing case studies and collecting data from farms with varying levels of biosecurity, researchers can advance our understanding of the relationship between these measures and the incidence of salmonellosis. Such insights are crucial for optimizing biosecurity strategies to improve overall poultry health and ensure public safety.

Although vaccination offers partial control of *Salmonella* in poultry, additional strategies are required. Biosecurity measures serve as the first line of defense and remain among the most cost-effective and efficient methods for preventing and controlling diseases in the poultry industry. Proper biosecurity management can substantially reduce the risk of introducing infections and it is essential for controlling salmonellosis. Specific biosecurity practices, including controlled farm access, strict hygiene protocols and regular flock monitoring for *Salmonella*, have been shown to significantly decrease the prevalence of *Salmonella* in poultry. Studies have demonstrated that farms adhering to rigorous biosecurity protocols report lower rates of salmonellosis outbreaks, highlighting the correlation between these practices and reduced infection rates. However, further research is needed to elucidate the specific contributions of biosecurity measures to mitigation and control of salmonellosis in poultry, ensuring that these practices are continually optimized to protect both animal health and public safety (Tilli et al., 2022).

WHAT IS BIOSECURITY?

Biosecurity is a key tool for effective management and an essential component of any successful poultry production system. Biosecurity encompasses a set of measures aimed at reducing the risks of introducing microorganisms and preventing the development and spread of diseases both inside and outside the poultry farm. In addition to maintaining flock health and well-being, implementation of conservation measures also improves productivity and ensures production of food that is safe for consumers (Torremorell, 2021). Any entity entering a poultry farm – including people, poultry, feed, vehicles, equipment, eggs, pests, rodents, insects (e.g. cockroaches), wild animals, domestic pets or other types of poultry – poses a potential risk of introducing diseases. Pathogens (bacteria, viruses, fungi, parasites both external and internal) are living microorganisms that cause infections or death. Diseases can spread rapidly on farms, causing great economic losses, especially in commercial production systems (Shoaib et al., 2018). Identifying potential routes of pathogen introduction is the first step in implementing an effective biosecurity program. Disease outbreaks can arise from numerous potential causes, frequently involving a combination of several factors leading to illness and/or mortality (Torremorell, 2021).

To eliminate the risks of disease outbreaks and protect public and poultry health, all individual and entities dealing with these issues should be trained and informed about the causes of diseases, modes of transmission, and implementation and efficacy of modern biosecurity procedures. In a qualitative study conducted by Souillard et al.

(2024), interviews with farmers revealed that 81% of farmers responded that they “always implement” biosecurity measures in their poultry farms. On the other hand, the main reasons for not implementing these measures included doubts about their efficiency, as these farmers perceived them as ineffective. Other stated reasons for not implementing biosecurity measures included: lack of awareness and insufficient understanding of the benefits of biosecurity, lack of training and support as well as insufficient time and financial constraints.

HOW CAN BIOSECURITY PROCEDURES PROTECT THE FLOCK?

Unfavorable conditions in poultry housing and stress can increase susceptibility to diseases. Farmers who manage poultry farms must provide adequate rearing conditions, taking into account the specific type, developmental stage, adaptation and physiological needs of the poultry. Biosecurity measures must be maintained at all times. The main biosecurity practices in commercial poultry production include: minimizing farm visitors, cleaning and disinfection protocols, isolating poultry, controlling vehicle entering the farm, managing pests and rodents and proper disposal of corpses (Russell, 2012).

Every poultry farm should have an easily accessible and clearly visible biosecurity plan. Individuals involved in poultry production should complete basic biosecurity training relevant to the type of production, with the objective of understanding its implications for animal health, human health and food safety. Records should also be kept to ensure traceability at all stages in the production chain, including data on poultry health, production, drug use, vaccination, etc. Poultry health should be monitored under the supervision of a veterinarian. To prevent the emergence of antimicrobial resistance, antimicrobial agents should be used in accordance with the veterinary prescriptions and manufacturer instructions. Regarding the location of the facilities, an isolated geographical location is recommended to minimize contact with other facilities, i.e. at least 500 meters from other farms (Delpont et al., 2021). Farms should be situated outside urban centers and others production systems, especially pig farms, and surrounded by a protective fence to establish a clearly defined biosecurity zone. Farm infrastructure must have protection from the external environment, preventing the entry of insects, rodents and wild birds. If other animals are raised on the poultry farm, any potential contact must be avoided (Meirhaeghe et al., 2019). Farms must also provide protection from solar radiation, strong winds and rain. Access to the facilities should be controlled, with mechanisms for cleaning and disinfection to minimize the movement of microorganisms and ensure biosecurity on the farm. Poultry farms should be supplied with drinking water for the poultry and technical water for cleaning and sanitation which must meet the legally defined requirements. Farms should be equipped with adequate lighting and ventilation systems, systems for monitoring and controlling temperature and humidity to maintain a biosecure environment for both poultry and staff. The construction materials used for farms should allow and facilitate adequate cleaning and disinfection. Farms should be designed to accommodate one kind and one production type, in accordance with the “all-in, all-out” principle for each group (Dewulf and Van Immerseel, 2018).

An important aspect of biosecurity measures involves the practices carried out by poultry farm staff and external visitors. Farm workers must have good hygiene practices. They should use protective clothing, and there should be dedicated areas or separate rooms for changing clothes and shoes, located away from the production zone. Entry to poultry housing facilities should have shoe barriers containing appropriate disinfectants, used according to the manufacturer's instructions and replaced regularly (Meirhaeghe et al., 2019). The entry of visitors and their movement on the farm should be recorded, and visitors are required to follow all biosecurity procedures. Farm staff must keep records of all processes carried out on the farm, including equipment maintenance, vehicle entry and exit, disinfection procedures, details of sick birds, mortality, etc. Each production facility should have designated spaces at the entrance for washing and disinfecting hands. It is recommended that persons who have recently visited other poultry farms or have symptoms of respiratory or gastrointestinal disease should be restricted from entering the farm. An important procedure for farm visitors is to change into clean clothes and shoes provided on the farm. If this is not practicable, they should be provided with clean outer clothing (head coverings, coats and protective footwear). Farm staff are required to report any travel abroad, particularly if it involved contact with other birds or pigs (Russell, 2012).

Effective cleaning and disinfection are fundamental to any biosecurity cleaning program, reducing the number of pathogens and the risk of disease outbreaks. Prior to disinfection, all organic matter should be carefully removed. Disinfection should be performed in the facilities, storage areas, equipment and the surrounding environment (Andries, 2023).

EGGS AND POULTRY PRODUCTION

The production area in poultry farms must be clearly demarcated from other parts of the facility. Defining the production area establishes a boundary between the potential contamination and production facilities. People or objects entering into the production area increase the risk of contaminating eggs and poultry with *Salmonella*. One of the main routes through which *Salmonella* can be introduced into poultry flocks is through movement of contaminated people, feed, equipment or materials (Dewulf and Van Immerseel, 2018). Controlling visitors, keeping records and adhering to entry protocols can significantly reduce the risks of introducing bacteria into poultry flocks. The entrance to production areas must be clearly marked to ensure compliance with important biosecurity measures. All entries in the production zone should provide soap and water, or a means for disinfection, washing and hand hygiene. The use of boots and protective shoes can significantly reduce the possibility of introducing *Salmonella* into the facilities (Correia-Gomes et al., 2021). Vehicles that do not need to enter the production zone should be parked in separate areas external to the production zone. If vehicles enter the production area, tires and vehicle should be disinfected. The poultry housing facilities, facilities for packing and section of eggs in the production area must be built and maintained to prevent entry of wild birds and minimize pest access. These animals often move between properties and can bring unwanted diseases (many animal species, wild birds and rodents can be *Salmonella* carriers) (Meirhaeghe et al., 2019).

Plastic egg racks should be disinfected before use, transport or storage to prevent spreading of bacteria. It is important to use new or disinfected racks for packing eggs to minimize the risk of further spreading of bacteria and other pathogens. Pallets used for storage and transport of eggs should be cleaned and disinfected, removing visible organic matter as much as possible. To further reduce the risk, one farm should use the same pallets. Palettes used to store and transport eggs should be kept clean, in safe places not inhabited by rodents (Russell, 2012).

Transport has an important role in disease prevention. During transport, poultry can be at risk of infection with various infectious diseases, exposure to pests (e.g. rodents), bodily fluids, contaminated trailers, equipment and people. Strict biosecurity measures are recommended from the point of loading, during transport to arrival at the final destination (Elniema et al., 2018). The transport trucks and trailers should be equipped with solid roofs and air-permeable sidewalls to control environmental factors such as temperature, humidity, oxygen levels and ventilation. Poultry must not be exposed at extreme temperatures, and equipment must not be shared between multiple poultry farms. Before feeding the poultry, all organic matter should be removed and trailers cleaned and disinfected. All personnel involved in poultry transport should wear protective clean clothing and footwear. Truck cabs should always be clean to prevent cross-contamination (Mitchell and Kettlewell, 2009).

CONCLUSION

Salmonella control programs, mainly targeting poultry production, have significantly reduced salmonellosis in a number of countries. Biosecurity is an important tool, essential for ensuring poultry health and welfare on poultry farms. Optimal outcomes in poultry farming depend on the health of the birds, as healthy hens are more efficient producers, supplying safe and high-quality eggs in the food chain. High biosecurity standards, by reducing the incidence of *Salmonella*, are essential for poultry flocks and for protecting public health. Insufficient biosecurity practices, however, can cause disease outbreaks, potentially leading to the compulsory slaughter of the flock. By implementing biosecurity measures, the risks of *Salmonella* and other microorganisms can be minimized.

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Authors' ORCID iDs: Simona Naumovska  (<https://orcid.org/0009-0002-4867-2554>); Annamaria Galfi Vukomanović  (<https://orcid.org/0000-0002-5361-1070>); Marko Pajić  (<https://orcid.org/0000-0003-4221-2602>); Slobodan Knežević  (<https://orcid.org/0000-0001-6316-5863>); Biljana Đurđević  (<https://orcid.org/0000-0002-1705-7615>); Bojana Blagojević  (<https://orcid.org/0000-0003-4255-6130>)

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