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Bacterial contamination of chicken eggs: A review

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Abstract
Foodborne infections are a major global health hazard; and contaminated hens eggs are especially dangerous. This review highlights onto the microbial contamination of chicken eggs, with a particular emphasis on the many pathogens that can enter eggs and remain there for the duration of their shelf life. The mechanisms of contamination are explained, emphasizing the significance of variables like handling practices, storage conditions as well as methods of egg production. It also looks at how the quality of egg shells affects foodborne infections, furthermore, highlighting how crucial shell integrity is to stopping pathogen penetration. The study also explores the controversy around egg washing techniques and the necessity to strike a balance between maintaining hygiene and protecting the inherent defenses of the eggshell. To sum up, this review sheds light on the microbiological hazards connected to chicken eggs and emphasizes the significance of strict.

Keywords: Chicken eggs, egg production, handling procedures, eggshell quality, foodborne infections

Introduction
Foodborne illnesses are a major public health issue that affects both developed and developing countries equally. One food item that is extremely susceptible to contamination is eggs (Abebe, Gugsa, and Ahmed 2020) [1]. Actually, 65 percent of the world's eggs are produced in Asia (Zaheer 2015) [25]. Microbial contamination, however, continues to be a persistent worry despite the egg's inherent defense mechanisms, which include the eggshell, shell membranes, yolk and albumin (Mkangara 2023) [19].

Eggs are vulnerable to contamination by various pathogens, including *Campylobacter jejuni*, *Escherichia coli*, and particularly Enterobacteriaceae. Staphylococci are frequently implicated in eggshell spoilage, often associated with factors like cracked eggs, damaged shells, and unsanitary conditions (El Ftouhy *et al*. 2022) [7]. Both the egg production process and the handling procedures that follow may result in contamination. Contamination poses a risk to the internal quality of the egg since it can seep through the eggshell, the yolk, the white and the eggshell and its membranes. Interestingly, *Salmonella enteritidis* can multiply in just two hours after exposure by quickly infiltrating follicular cells (Mahmoud *et al*. 2022) [18].

Because they can include germs like Enterobacter and other intestinal pathogens, eggs have become known as a common source of foodborne diseases (Moi *et al*. 2022) [20]. Animal and human food poisoning is often caused by enteric microbes such as *E. Coli*, *Listeria*, *Staphylococcus aureus* and Campylobacter (Bintsis, 2017) [3]. Taking into account the rising demand for eggs due to the significant rise in egg production in Iraq from 1.5 million to 4.5 million between 2004 and 2019, strict quality control procedures become imperative. This includes identifying and controlling contaminating bacteria, such as Enterobacter, Bacillus, Pseudomonas, and Salmonella species, which might arise from the environment or the intestinal flora of laying hens (Fawzi and Alwasity 2021) [8].

Egg production systems can be broadly categorized into industrialized and non-industrialized systems. Industrialized systems often incorporate disinfection measures during packaging, whereas non-industrialized systems typically sell fresh eggs in bulk without adequate sanitary precautions (Gandarillas *et al*. 2023) [9]. Consequently, the risk of microbial contamination may vary between these two systems, warranting a closer examination of the microbial quality of eggs, particularly those packaged and sold in establishments with potentially less stringent hygiene practices (Grumezescu and Holban 2017) [13]. The aim of current study is to evaluate the microbial contamination of chicken eggs.

Mechanisms of bacterial contamination in eggs

There are various ways might cause contaminate eggs by pathogenic bacteria, and there are a number of foodborne pathogens that can enter the egg and remain there for the duration of its shelf life (Kabiraz *et al*. 2023) [14]. On the surface of the eggshell and the egg albumen as shown in Figure 1, respectively, pathogenic fungi and mycotoxins have also been found in addition to Gram negative and Gram positive bacteria (Tomczyk *et al*. 2018) [24].

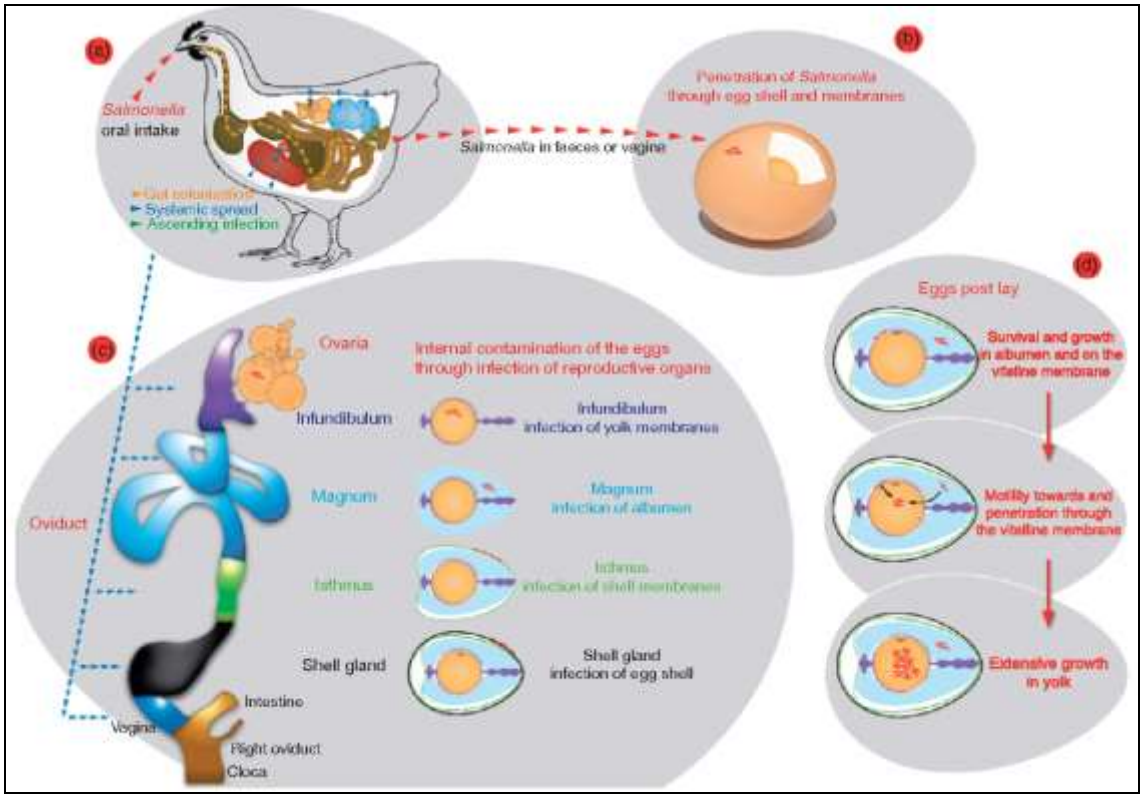

Fig 1: Mechanisms of chickens egg contamination (Gantois *et al*. 2009) [10]

Table eggs contaminated with bacteria

Considerable investigation has been conducted on the topic of bacterial contamination of table eggs. Total viable count (TVC) on eggshells plays an important role in egg safety and product shelf life, which makes it a topic of great interest. Regulators in some, but not all, countries propose acceptable TVC levels for eggs or egg products. Season, housing arrangement, farm and flock management, cleanliness in egg storage locations, and egg handling techniques all affect the TVC on eggs (Chousalkar, Khan, and McWhorter 2021) [5].

Eggshell quality and the possibility of foodborne infections: Because eggs with stronger eggshells are better able to resist pathogen penetration and internal content contamination, eggshell quality is evaluated in order to develop techniques for lowering the risk of foodborne infections (Gole *et al*. 2014) [11]. A flock's age, food, stressors, and genotype all have an impact on the cuticle, palisade, vertical crystal, mammillary, and shell membrane composition (Cheng and Ning 2023) [4]. These factors also have an impact on microbial penetration into the egg's interior. When hens get older, the outermost protective layer, the cuticle, frequently becomes thinner in older hens. The first line of defense against infections on the eggshell surface is weakened by this thickness loss (Kulshreshtha *et al*. 2021) [15]. Furthermore, hens under stress or on an inadequate diet may lay eggs that have thinner shells or reduced shell integrity, which can result in microcracks in the shell. The danger of contracting a foodborne illness can be elevated by bacteria such as Salmonella finding a way into the egg albumen and yolk through these minor fractures that are imperceptible to the human eye (EFSA Panel on Biological Hazards (BIOHAZ) 2014).

Foodborne pathogens and egg storage

Several post-lay control techniques, such as cleaning and cold-temperature storage, are used to reduce the amount of bacteria on eggshells (Saleh *et al*. 2020). While washing eggs is discouraged or outright forbidden in many countries as example in the UK and the EU, it is a widespread practice in the USA, Japan, and Australia (Onyena *et al*. 2021). Conditions for storing eggs in the downstream supply chain are very different after oviposition. For instance, the USA mandates that all eggs be kept at 7.2 °C or lower the entire supply chain. Other countries may have different regulations or rely on alternative strategies (An *et al*. 2023).

Cold storage, regardless of location, remains a crucial practice. Lower temperatures inhibit bacterial growth and multiplication on the eggshell, significantly reducing the risk of foodborne pathogens like Salmonella from multiplying to infectious levels (Silva *et al*. 2022) [22]. However, concerns exist regarding cold storage and the integrity of the eggshell's natural protective cuticle. Washing, when practiced, aims to remove potential contaminants from the eggshell surface. However, this process can also remove the cuticle, potentially increasing the risk of bacterial penetration through microscopic pores in the shell. This highlights the ongoing debate surrounding egg washing practices and the need for a balance between

hygiene and preserving the eggshell's natural defenses (Kulshreshtha *et al*. 2022) [16].

Conclusion

As a result, present review clarifies the microbiological hazards concerning to chicken eggs and emphasizes how crucial strict quality control procedures are to guarantee egg safety. The results emphasize that, in order to reduce contamination, attention must be taken in the handling, storage, and production operations of eggs. Furthermore, the study highlights the ongoing controversy around egg washing methods and the need of high-quality eggshells in preventing foodborne illnesses. The public's health can be protected by reducing the danger of foodborne illnesses linked to chicken eggs by applying suitable measures and comprehending the mechanisms of contamination.

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