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Escherichia coli Contamination of Chicken Table Eggs in Maiduguri, Northeastern Nigeria: A Potential Public Health Concern

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Abstract

Escherichia coli is a common inhabitant of the gastrointestinal tract of humans and animals, including poultry. While most strains are non-pathogenic, their presence in food is widely recognized as an indicator of faecal contamination. This study investigated the prevalence of E. coli contamination in table eggs and their components across selected locations in Maiduguri, Borno State, Northeastern Nigeria. A total of 100 eggs were collected from the University of Maiduguri Animal Farm, Monday Market, Gamboru Market, and Baga Road Market. Each egg was separated into yolk, albumen, and shell, which were cultured on Eosin Methylene Blue agar, and presumptive isolates were confirmed by microscopic examination of thin smear preparations. An overall prevalence of 51% was recorded for E. coli. The highest location-based prevalence of 72% was observed in Gamboru Market followed by 64%, 56% and 12% for Monday Market, Baga Road Market and Animal Science Research Farm of University of Maiduguri respectively. A slightly higher prevalence of 33.0% for albumen was observed compared to 32.0% each for eggshell and egg yolks. These findings underscore the need for strict hygienic practices at both farm and retail levels, including the inspection of cracks, removal of dirty eggs, appropriate washing, and proper storage conditions, to ensure the microbial safety of eggs intended for human consumption.

Keywords: Table eggs; *Escherichia coli*; Light microscope; Maiduguri; Prevalence

INTRODUCTION

The avian egg is biologically designed to support embryonic development and, as such, possesses a complete natural life-support system with multiple protective barriers that inhibit bacterial penetration and proliferation [1]. These structural defenses not only safeguard the embryo but also protect the egg during its passage from the hen to the consumer [2]. Although most freshly laid eggs are reported to be sterile, they can become contaminated under certain conditions [3]. This is particularly critical because eggs provide an optimal nutrient-rich medium capable of supporting the growth of both spoilage organisms and pathogenic agents [4]. The egg is composed of three principal protective layers: the cuticle, outer shell, and the inner shell membrane. Each contributes to varying degrees, in restricting microbial invasion [5]. Nevertheless, eggs remain vulnerable to contamination either vertically (trans-ovarian, before laying) or horizontally (after laying) from multiple environmental and management sources. Such contamination may occur via the cloaca, nesting material, soil, dust, litter, avian faeces, or through inappropriate handling practices including washing methods, type of detergent used, washing solution characteristics (temperature and pH), storage in high humidity, and poorly sanitized equipment [6].

Within traditional Nigerian diets, apart from livestock meat and fish, eggs serve as a major source of high-quality protein for human consumption [7,8]. However, eggs may become contaminated with enteric bacteria such as *Salmonella*, *Escherichia coli*, and *Staphylococcus* species, which are associated with egg-borne infections [9]. *E. coli* is a common commensal inhabitant of the gastrointestinal tract of poultry, ruminants, and humans. While most strains are harmless, certain pathogenic variants pose significant risks to food safety and public health [10,11]. Infections due to egg-associated *E. coli* can lead to acute gastrointestinal disorder characterized by nausea, vomiting, diarrhoea, abdominal pain, and, in severe cases, mortality, particularly among children [12, 13]. Earlier surveys employing Congo Red binding assays had shown that more than 90% of *E. coli* isolates exhibit pathogenic potential [14]. Over the past two decades, foodborne outbreaks of pathogenic *E. coli*, notably serotype O157:H7, have been widely reported and linked to severe gastrointestinal diseases [15]. Several global epidemics due to colibacillosis have also been traced to egg consumption, implicating pathogens harboured within the shell or contents of poultry eggs [16, 17]. In this context, the present study was undertaken to assess the prevalence of *E. coli* in raw table eggs and egg-derived products marketed for human consumption in Maiduguri, Northeastern Nigeria.

Materials and Method

Study Area

The study was conducted in Maiduguri, the state capital and largest urban centre of Borno State, located in Northeastern Nigeria. Maiduguri lies within the Lake Chad Basin, along the seasonal Ngadda River, and is geographically positioned at latitude 11.85° N and longitude 13.16° E.

Study Design, Sample Collection and Laboratory Analysis

A cross-sectional study design was employed. A total of 100 table eggs were conveniently collected from four locations, which comprised Animal Science Research Farm in University of Maiduguri, Monday Market, Gamboru Market, and Baga Road Market. The samples were then transported to the Department of Veterinary Microbiology for laboratory analysis. Eosin Methylene Blue (EMB) media (Guandong Huankai Microbial Science and Technology Co. Ltd: HCMO44) was prepared based on Manufacturer's instruction. A given quantity (36 g) of EMB was suspended in conical flask containing 1000 ml of distilled water, heated to a boiling point at 100 ^{o}C to dissolve completely. The prepared media was then sterilized by autoclaving at 121 ^{o}C pressure for 15 minutes and cooled to 45 ^{o}C. A pre-determined volume (20 ml) of the media was dispensed into each petri dish and left overnight in a laminar air flow to form gel. For sampling from the shells, sterile swabs moistened with 0.9% normal saline were rubbed over the egg surface and inoculated onto freshly prepared EMB plates. For internal content sampling, eggs were disinfected by immersion in 75% ethanol for 5 minutes, followed by brief flaming (5–10 seconds) at the blunt end. A sterile thumb forceps was used to perforate the shell, and the yolk and albumen were aseptically transferred into separate sterile polythene bags. Using sterile wire loops, aliquots of yolk and albumen were streaked onto EMB agar plates. All inoculated plates were incubated aerobically at 37 °C for 24 hours.

Bacterial growth was assessed based on colonial morphology. Presumptive *Escherichia coli* colonies were identified as flat, dark colonies exhibiting a characteristic metallic green sheen on EMB agar, consistent with established descriptions [18].

Data Analysis

Descriptive statistics were applied. Results were expressed as percentages and tabulated using Microsoft Excel 2016.

Results

Prevalence of *E. coli* in raw egg and its products in Maiduguri, Borno State, Nigeria.

Out of the 100 table eggs examined, *E. coli* was detected in 51 of the samples, giving an overall prevalence of 51.0%. The highest location-based prevalence of 72% was observed in Gamboru Market followed by 64%, 56% and 12% for Monday Market, Baga Road Market and Animal farm University Maiduguri respectively (Table 1).

Table 1: Prevalence of *E. coli* in raw egg and its products in Maiduguri, Borno State, Nigeria.

Location	No. of egg tested	No. of egg Positive	Prevalence (%)
Animal Farm	25	3	12
Gamboru Market	25	18	72
Monday Market	25	16	64
Baga Road Market	25	14	56
Overall	100	51	51

Prevalence of *E. coli* within egg components sampled in the study location

E. coli prevalence among the test egg shells was found to be 32.0%, while that of abumen and egg yolk components were 33.0% and 32.0% respectively (Table 2).

Table 2: Prevalence of *E. coli* in egg components in Maiduguri, Borno State, Nigeria.

Egg Component	No. of egg tested	No. of egg Positive	Prevalence (%)
Egg shell	100	32	32
Albumen	100	33	33
Egg-yolk	100	32	32

Plate 1: *E. coli* colonies on EMB agar

Characteristic greenish metallic sheen of *E. coli* on EMB

Discussion

The 51.0% prevalence of *Escherichia coli* on table eggs offered for sale in the study area is indicative of appreciably high egg contamination with the pathogen. The findings from this study carry significant public health implications especially when the eggs are inadequately cooked or boiled before consumption. Eggs are widely consumed across the globe due to their nutritional and health benefits [19]. People from this region that form the habit of consuming raw or improperly cooked eggs are profoundly predisposed to contact foodborne colibacillosis on a frequent basis [20]. Moreover, this bacterium can act as an opportunistic pathogen in immuno-compromised. persons causing extra-intestinal infections involving septicemia, urinary tract, lung tissue, joints, meninges of the brain and others [10].

Unfortunately, this disease-causing agent could also be commensal in nature [21]. Table eggs can be easily contaminated during handling and storage, therefore, they may serve as a vital medium for the transmission of *E. coli* to humans [22, 23]. The prevalence of *E. coli* recorded in this study is comparatively higher than reported in other studies elsewhere in Nigeria and Morocco [24, 25]. Such discrepancies may be attributed to differences in the farm management practices, egg handling, storage procedures, and hygienic conditions at production or retail outlets. Moreover, longevity and integrity of internal structures of eggs also play critical roles in facilitating microbial contamination or invasion. Furthermore, nutrients found in eggs provide an excellent media for bacterial growth and development [8]. Previous studies reported the prevalence of 38.6% and 40.3% for bacterial contamination in table eggs [26, 27].

With respect to study location, the prevalence was more pronounced in the markets compared to the Animal Science Research Farm. This could be associated with the hygienic status of the locations and storage facilities of the eggs, as it was previously suggested that good hygienic measures are important to maintain the quality and safety of eggs [8]. Therefore, storage conditions at retail outlets significantly impact the bacterial survival within the egg. Additionally, within the markets, contaminated eggs and their crates coming from different poultry farms might also be a good source of possible contamination to sterile ones [28].

Regarding the egg components, there was very little or no apparent difference with respect to *E. coli* contamination of the contents comprising egg shells, albumen and egg-yolk. In some instances, there were overlaps where contamination is detected in more than one component of the same egg. Surprisingly, the present study recorded high level contamination of the egg components, despite their antimicrobial properties which have been extensively documented [29, 30]. In our opinion, the antimicrobial activities of these components might have been more effective against Gram-positive bacteria or rendered ineffective with the magnitude of contamination by this organism.

In conclusion, this study demonstrated that table eggs marketed in Maiduguri metropolis are frequently contaminated with *E. coli*, underscoring a potential health risk to consumers, particularly those who consume raw or undercooked eggs. Strengthening hygienic practices including proper handling, washing with appropriate detergents, inspection for cracks and dirt, and storage under controlled conditions at both farm and retail outlets is imperative to minimize health risks. Public health awareness campaigns to discourage the consumption of raw or insufficiently cooked eggs are also recommended towards mitigating the associated hazards.

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