Original Research Article

Potential risk of some pathogens in table eggs

EL-Kholy, A.M., Saadia H. EL-Shinawy, Hemmat Seliem, Mohamed M.A. Zeinhom
Food Hygiene and Control Department, Faculty of Veterinary Medicine, Beni-Suef University, Beni Suef. 62512, Egypt.

ABSTRACT
This study was conducted to record the potential risk of some pathogens in table eggs in Beni-Suef city, Egypt. A total of 100 table eggs samples (Farm and Baladi eggs) were randomly collected from poultry farms, markets, supermarkets and groceries in Beni-Suef city. 50 farm eggs samples (each of 3 eggs) and 50 baladi eggs samples (each of 5 eggs) were examined for the presence of coliforms, E.coli, Salmonella, coagulase positive Staphylococcus aureus and Staphylococcal enterotoxins. Isolates were identified by biochemical, serological and molecular (PCR) methods. The obtained results in the present study revealed that (22%) of the examined samples were contaminated with Coliforms. The other identified genera were Citrobacter freundii, Citrobacter diversus, Edwardsiella tarda, Enterobacter spp., Morganella morganii, Klebsiella oxytoca, Providencea spp., Serratia fonticola and Yersinia intermedia. E.coli (atypical type) was detected in a percentage of 27.27%. True fecal E. coli and Salmonella spp. failed to be detected in any of the whole examined 100 eggs samples. Additionally, Staphylococcus spp. was detected with incidence rate of (13%), out of them, 8 (61.5%) isolates were accounted for coagulase positive Staphylococcus aureus. Enterotoxin profiling revealed that two classical enterotoxin genes (SEA and SED) were detected either singly or in combination. The potential health hazards and the suggested control measures of the isolated strains had been discussed.

ARTICLE INFO
Article history:
Received
10/9/2019
Accepted
8/12/2019
Online 1/2/2020

Keywords:
Baladi eggs, Coagulase positive, Coliforms, Enterotoxin, E.coli, Poultry farms, Salmonella, Staphylococcus aureus, Table eggs

*Corresponding author: Hemmat Seliem: Food Hygiene and Control Department, Faculty of Veterinary Medicine, Beni-Suef University, Beni Suef. 62512, Egypt.
Email: hemat.seleem@gmail.com
1. Introduction

Eggs are truly an inexpensive and highly nutritious food that can be considered a nutritious formula in the diet for people of all ages and at different stages of life. On average, the macronutrient content of eggs includes proteins, lipids and low carbohydrates (Papadopoulou et al., 1997; MAFF, 2000). Eggs supply the diet with several essential nutrients such as zinc, selenium, retinol, tocopherols and contain 18 vitamins and minerals. Most eggs have been found to be nearly sterile when laid, but they have the potential to become occasionally contaminated (Egg Nutrition Center (ENC), 2004; Egg safety center (ESC), 2010). Fresh egg contains a nature of physical barriers; the shell, cuticle and membranes that prevent microorganisms from gaining access to its contents. In addition, the albumen (egg white) contains substances that limit the growth of microorganisms (Jay et al., 2005, Gantois et al., 2009a). Human and hens can be a source of contamination of the eggs’ shell (Gast and Holt, 2001, Ricke et al., 2001). The surface of an egg can be contaminated with any microorganisms before it is laid or after laying with the avian fecal matter, nesting material, dust, feedstuff, shipping and storage containers (Al-Bahry et al., 2011) which is favored by high humidity and temperature leading to spoilage and economic losses or causing a public health hazard (Board and Fuller, 1994) The main isolated food-borne pathogens from table eggs and its contents are Escherichia coli, Salmonella spp. and Staphylococcus aureus (Adesiyun et al., 2005, Gole et al., 2013).

E. coli is considered an important pathogen of human diarrheal disease isolated from table eggs. Although most strains of E. coli inhabit the normal gut flora of humans and animals (Brooks et al., 1995), E. coli had been isolated from table eggs’ shells and their contents (Hope et al., 2002, Adesiyun et al., 2005). Salmonella species is considered the most important cause of food-related illness as they lead to more deaths than any other food-borne pathogen. Salmonella can cause illness on consumption of raw or undercooked eggs (FDA, 2010, USDA, 2011, CDC, 2017). Other members of Coliforms such as Citrobacter spp., Enterobacter spp., Klebsiella spp., Serratia spp. and Providencia spp. have all the potential to cause spoilage of table eggs causing infection in consumers (Musgrove et al., 2004; Musgrove et al., 2008). Staph. aureus contaminates different kinds of food. On the other hand, coagulase positive Staph. aureus is considered the most important species of Staphylococcus spp. as it evokes pathogenic effect and produces enterotoxins which cause food toxication (Abeer, 1997). Staph. aureus is transmitted via people-to-food through improper handling and they are mainly found in restaurants or picnics as food is not properly refrigerated or stays out of the refrigerator too long (Songer and Post, 2005) and (Cha et al., 2006) The staphylococcal enterotoxins (SEs) are the products of Staph. aureus and are recognized as the causative agents of classical food poisoning in humans following the consumption of contaminated food (Ikeda et al., 2005). Staph. aureus enterotoxins are of several types; A–E, G, H, I and R–T, which are commonly produced either singly or combined by most strains of Staph. aureus (Argudín et al., 2010). Eggs are involved in outbreaks of Staphylococcal enterotoxication (Yang et al., 2001, Shareef et al., 2009).

Therefore this study was executed to evaluate the potential risk of some pathogens in table eggs collected from groceries and supermarkets located in Beni suef city, Egypt.
2. Materials and Methods

2.1. Collection of samples A total of 100 table eggs samples (Farm and Baladi eggs) were randomly collected each from poultry farms, markets, supermarkets and groceries in Beni-Suef City, 50 farm eggs samples (each of 3 eggs) and 50 baladi eggs samples (each of 5 eggs). Each sample was placed in a sterile plastic bag and carried to the laboratory without delay where they were prepared and examined microbiologically.

2.2. Preparation of samples

Egg content: The eggs were prepared for evacuation of its content according to (APHA, 2004).

2.3. Microbiological examination

1- Isolation and identification of Coliforms and E. coli from egg contents were carried out according to (Cheesbrough, 2006).

2- Isolation and identification of Salmonella from egg contents were performed according to (Cheesbrough, 2006).

3- Isolation and identification of coagulase positive Staphylococcus aureus were done according to (AM, 2003, ISO, 2003b).

4- Molecular identification of coagulase positive S. aureus gene (COA) and enterotoxin genes (A, B and D) by PCR was implemented according to (Mehrotra, 2000, Iyer and Kumosani, 2011).

3. Results

Table 1. Incidence of Coliforms in the examined table eggs samples

| Type of egg samples | No. of the examined samples | No. of positive | % |
|---------------------|----------------------------|----------------|---|
| Baladi              | 50                         | 20             | 40|
| Poultry farm        | 50                         | 2              | 4 |
| Total               | 100                        | 22             | 22|
Table 2. Coliform isolates obtained from the examined table eggs samples

| Bacterial isolates       | Baladi egg samples | Poultry farm eggs samples |
|--------------------------|--------------------|--------------------------|
|                          | NO     | %       | NO     | %       |
| **Citrobacter freundii** | 2      | 10      | -      | -       |
| **Citrobacter diversus** | 1      | 5       | -      | -       |
| **Atypical E.coli**      | 6      | 30      | -      | -       |
| **Edwardsiella tarda**   | 2      | 10      | -      | -       |
| **Enterobacter spp.**    | -      | -       | 2      | 100     |
| **Morganella morganii**  | 1      | 5       | -      | -       |
| **Klebsiella oxytoca**   | 1      | 5       | -      | -       |
| **Providenciae spp.**    | 3      | 15      | -      | -       |
| **Serratia fonticola**   | 2      | 10      | -      | -       |
| **Yersinia intermedia**  | 2      | 10      | -      | -       |
| **Total**                | 20     | 90.9    | 2      | 9.1     |

Fig. 1 Frequency of Coliform Isolates in table eggs samples
Table 3. Incidence of *Staphylococcus* spp. in the examined table egg samples

| Type of eggs   | No. of examined eggs | No. of positive samples | No. of Coagulase positive samples | No. of Coagulase negative samples |
|---------------|----------------------|--------------------------|-----------------------------------|----------------------------------|
|               |                      |                          | No | % | NO | % | No | % |
| Baladi        | 50                   | 7                        | 14 | 71.4 | 5 | 28.6 | 2 | 28.6 |
| Poultry farm  | 50                   | 6                        | 12 | 50  | 3 | 50  | 3 | 50  |
| Total         | 100                  | 13                       | 13 | 61.5 | 8 | 38.5 |

Table 4. Molecular identification of coagulase (CoA) gene positive *Staph. aureus* strains recovered from the examined egg samples

| No of tested Isolates | No of identified CoA S.aureus strains | % |
|-----------------------|---------------------------------------|---|
| 8                     | 8                                     | 100 |

Fig. 2 PCR result for the coagulase positive *Staph. aureus* strain (CoA gene) (630bp). Lane L: DNA ladder, Lane Neg.; control –ve, Lane Pos.; control +ve, Lane 1, 2, 3, 4, 5, 6, 7 and 8: CoA *S. aureus* isolates
Table 5. Occurrence of enterotoxin genes (A+D) in coagulase positive *Staph. aureus* strains recovered from the examined table egg samples

| Tested samples | CoA gene | SEA | SE D | SE A+D |
|----------------|----------|-----|------|--------|
| 1              | +        | -   | -    | -      |
| 2              | +        | +   | -    | -      |
| 3              | +        | +   | +    | +      |
| 4              | +        | +   | -    | -      |
| 5              | +        | -   | -    | -      |
| 6              | +        | -   | +    | -      |
| 7              | +        | -   | -    | -      |
| 8              | +        | -   | -    | -      |
| **Total**      | **8**    | **3**| **2**| **1**  |

![PCR result for enterotoxin gene SEA (102 bp) among *Staph. aureus*](image)

Fig. 3 PCR result for enterotoxin gene SEA (102 bp) among *Staph. aureus* Lane L: ladder, lane Pos: control positive, lane Neg: control negative, lane 2, 3 and 4 (+ve SEA), lane 1, 5, 6, 7 and 8(-ve SEA).
4. Discussion

According to the results presented in Table (1), it was recorded that 20 (40%) Baladi eggs samples were contaminated with Coliforms, while only two (4%) of the Poultry farm eggs samples were contaminated with Coliforms.

Our results were nearly similar to those evoked by (Adesiyun et al., 2005, Abdullah 2010, Ghasemian Safaei et al., 2011, AL-Ashmawy 2013) while it was lower than those reported by (El-Kholy et al., 2014, Salihu et al., 2015) and higher than the results obtained by (Awny et al., 2018).

The results recorded in Table (2) revealed that the identified genera of Coliforms from the examined eggs samples were Citrobacter freundii, Citrobacter diversus, Atypical E. coli, Edwardsiella tarda, Mogonella morganii, Klebsiella oxytoca, Providencea spp., Serratia fonticola and Yersinia intermedia with the incidences of (10%), (10%), (5%), (30%), (10%), (5%), (5%), (15%), (5%) and (5%) from Baladi eggs samples, respectively. While only two (100%) Enterobacter species were isolated from examined farm eggs samples.

The presence of different members of Coliforms in eggs was recorded by different authors as (Papadopoulou et al., 1997, Jones et al., 2004, Musgrove et al., 2004, Adesiyum et al., 2005, Musgrove et al., 2005, Adesiyun et al., 2006, Obi and Igboke, 2007, Musgrove et al., 2008, Al-khalaf et al., 2009, Ansah et al., 2009; Abdullah, 2010, Stępień-Pyśniak et al., 2010, Gole et al., 2013, Awny et al., 2018).

Our study cleared that E.coli true fecal type and Salmonella spp. could not be detected in any of the examined eggs samples.

Many authors reported that Salmonella failed to be detected which agreed with findings of this study as (El-Leboudy et al., 2011,Ghasemian Safaei et al., 2011, Mahdavi et al., 2012, El-Kholy et al., 2014, Abdel-Latif and Saad, 2015, Lee et al., 2016). Higher percentages of Salmonella were illustrated by (Adesiyun et al., 2005, Evêncio-Luz et al., 2012, Ghazi and Amer, 2015, Amin, 2017, Awny et al., 2018, Al Momani et al., 2018). Failure to detect fecal E. coli in our results agreed with (Bahobail et al., 2012, Siriporn et al., 2015), while True fecal E. coli were shown with high incidence rate in the results of (Adesiyun et al., 2005, El-Kholy et al., 2014, Eid et al., 2015, Mansour et al., 2015, Elafify et al., 2016, Lee et al., 2016, Momani et al., 2018).
Regarding the increasing consumption of egg and its products, it is necessary to investigate egg contamination. The egg shell contamination occurs as a result of deposition of fecal matter on the shell, ovarian or oviduct and gut flora, debris material, egg crates, packing and storage, clothes and hands of poultry workers, dust and weather conditions or during transportation and marketing (Al-Bahry et al., 2012). The prevalence of Coliforms may be attributed to the poor hygiene; consequently, such eggs with high coliforms constitute an economic and public health importance (Sabreen, 2001), while the lower contamination rate of poultry farm eggs may be due to its hygienic laying, handling and the cleaning process of eggs before marketing. Coliforms have been used as indicator microorganisms which indicate the possibility of fecal contamination (Mahdavi et al., 2012) and the microbial quality and safety of the food and also reflect the hygienic standards adopted in the food operations (Roberts et al., 1995). *E. coli* is one of the major problems in chicken production influencing heavier losses and severe drop in egg production, about 5.5% mortality and 10-20% drop in eggs was observed with *E. coli* infections (Qu et al., 1997). *E. coli* can bring about urinary tracts infections, pneumonia, meningitis, peritonitis and induce profuse watery diarrhea in humans (Schiavoni and Vergora, 2000). *Citrobacter spp.* can cause a wide spectrum of infections in humans. Among the various sites of infection, the urinary tract is the most common, followed by the respiratory tract, and skin/soft tissues (Pavani, 2012). *Enterobacter spp.* were incriminated in urinary tract infection and septicemia, while *Klebsiella spp.* is a world wide spread bacteria that can be responsible for arthritis, meningitis, appendicitis, cystitis and septicemia outbreaks in kids and newborns, but is more frequently responsible for pneumonia and necrotic damage of the lungs (Bernabe et al., 1998). In our study *Salmonella* was not detected in any egg samples and this may be the result of strict control measures applied against these bacteria and may be attributed to the fact that poultry farmers practice strict medication and care as directed by the International Commission on the Microbiological Specification for Food (ICMSF, 2009). Regarding to the Egyptian Organization for Standardization and Quality Control; (E.O.S.Q.C, 2007) fresh table eggs must be free from *Salmonellae spp.* in their contents (Nil), so all examined eggs samples satisfy the standards in balady and farm hen eggs.

The summarized results in Table (3) revealed that the incidence of *Staphylococcus spp.* in the examined table eggs samples was (13%) out of them, 8 (61.5%) were coagulase positive *Staphylococcus aureus* (Table 4). The PCR result of the COA gene was enough to confirm the virulence of the *Staphylococci* isolates as it is considered a marker for its virulence.

Results of this study were lower than those reported by Abdullah, (2010) and Salihu et al., (2015), while higher than results illustrated by (Stepień-Pyśniak et al., 2009, Pyzik et al., 2014, Abdel-latif, 2015, Eid et al., 2015, Fardows et al., 2016, Rodriguez-Lázaro et al., 2017, EL-Nagar et al., 2017).

The results recorded in Table (5) revealed that enterotoxins were found in 4 out of 8 (50%) of *Staph. aureus* strains and these strains showed positive results for the presence of enterotoxin genes singly and in combination. The enterotoxin profiling recorded tow classical enterotoxin genes (SEA and SED) which were recovered from three and two *Staph. aureus* strains and detected at 37.5% and 25%, respectively, while only one *Staph. aureus* strain was positive for both SEA and SED genes (12.5%).
Our data agreed with (Fueyo et al., 2001, Yang et al., 2001, Çepoğlu et al., 2010).

Regarding to the Egyptian Organization for Standardization and Quality Control (E.O.S.Q.C, 2007) which stated that Staphylococcus aureus must not be found in egg content (Nil), it was noticed that there were 8 samples that failed to achieve the Egyptian Standard levels with incidences of 71.4% and 50% of Balady and Poultry farm eggs samples, respectively Table (3). Among the pathogenic food poisoning organisms that affect human, Staph. aureus organisms have a serious concern to public health (Wyah, 1992) causing Staphylococcal food-borne disease (SFD), which can be transmitted to eggs when handled by persons who have Staph. aureus infection. Also, eggs’ contents may be contaminated accidentally by Staph. aureus from the egg shell as it might have originated from ova during egg formation, dust and from the surface of inanimate objects (California Egg Commission, 1999) Staphylococcal enterotoxins (SE) constitute a family of biologically and structurally related toxins. The SEs are the main cause of many outbreaks of food borne diseases (Lamaita et al., 2005) as well as the classical food poisoning in humans (Balaban et al., 2000, Dinges et al., 2000).

5. Conclusion

We can recommend that strict hygienic measures to safeguard eggs from being contaminated with pathogenic bacteria causing food poisoning should be adopted in the farms and during production, handling and processing of eggs.

References

Abdel-latif, F.F. (2015). Microbiological Profile of Leaking Chicken Table Eggs. I.J.S.N.6 (1): 51-55.

Abdullah, I.N. (2010). Isolation and identification of some bacterial isolates from table egg. Al-Anbar J. Vet. Science, 3(2): 59-67.

Abeer, A.A. (1997): Organoleptic inspection and microbiological quality of different types of fermented milk. M.V.Sc. Thesis, Fac. Vet. Med., Cairo Univ.

Adesiyun, A., Offiah, N., Seepersadsingh, N., Rodrigo, S., Lashley, V., Musai, L. and Georges, K. (2005). Microbial health risk posed by table eggs in Trinidad. Epidemiol. Infect. 133: 1049-1056. Cambridge University Press.

Adesiyun, A., Offiah, N., Seepersadsingh, N., Rodrigo, S., Lashley, V. and Musai, L. (2006). Frequency and antimicrobial resistance of enteric bacteria with spoilage potential isolated from table eggs. J. Food Res Int 39 (2): 212-219.

AL-Ashmawy, Maha A. M. (2013). Prevalence of Enterobacteriaceae in table eggs with particular reference to entervirulent Escherichia coli strains. I. J. Poul. Sci. (7): 430-435.

AL-Bahry, S. N., Mahmoud, I. Y., Al-Musharafi, S. K. and Al-Ali, M. A. (2012). Penetration of spoilage and food poisoning bacteria into fresh chicken egg: A public health concern. Global J. Bio-Sci. Biotechnol. 1(1): 33-39.

AL-Bahry, S. N., Mahmoud, I. Y., Al-Rawahi, S. H. and Paulson, J. (2011). Egg contamination as an indicator of environmental health. In: Eggs Nutrition, Consumption and Health. NOVA Science Publishers, INC. New York, USA.

AL-khalaf, A. N., Akeila, M. A., Al-Dubaib, M. A., Azzam, A. H., ElShafey, A. A. and Draz, A. A. (2009). Bacterial Contamination of
Hatcheries. J. Agric. Vet. Sci., Qassim University, 2: 67-76.

AL Momani, W., Janakat, S. and Khatatbeh, M. (2018). Bacterial Contamination of Table Eggs Sold in Jordanian Markets. Pak. J. Nutr. 17: 15-20.

Amin, Wallaa. (2017). Incidence of Some Food-Borne Pathogens in Table Eggs in Assiut City, Egypt. IJTRD. 4(6): 75-78, ISSN: 2394-9333.

AM., Microbiology of food and animal feeding stuffs. (2003). Horizontal method for the enumeration of coagulasepositive staphylococci (Staphylococcus aureus and other species).

Ansah, T., Dzoagbe, G. S. K., Teye, G. A., Adday, S. and Danquah, J. K. (2009). Microbial quality of table eggs sold on selected markets in the Tamale municipality in the Northern Region of Ghana. Livestock Research for Rural Development. 21.

APHA, American Public Health Association. (2004): Standard methods for the examination of dairy products. 17th Ed. American public health association. Washington D.C.

Argudín, María Á., Mendoza, María C. and Rodicio, María R. (2010). Food Poisoning and Staphylococcus aureus Enterotoxins, Toxins (Basel). Jul; 2(7): 1751–1773, doi: 10.3390/toxins2071751.

Awny, Christina, Amer, Amr A., Abo El-Makarem and Hussein, S. (2018). Microbial Hazards Associated with Consumption of Table Eggs, AJVS.58 (1): 139-146. DOI: 10.5455/ajvs294480.

Bahobail, Abdul Aziz S., Sabry, A. Hassan and Bahig, A. El-Deeb (2012). Microbial quality and content aflatoxins of commercially available eggs in Taif, Saudi Arabia. AJMR. 6(13): 3337-3342. Available online at http://www.academicjournals.org.

Balaban, N. and Rasooly, A. (2000). Staphylococcal enterotoxins. Int. J. Food Microbiol. 61: 1–10.

Bernabe, A., Contreras, A., Gomez, M. A., Senchez, A., Corrales, J. C. and Gomez, S. (1998). Polyarthritis in kids associated with Klebsiella pneumonia. Veterinary Record. 142(3):64-66.

Board, R. G. and Fuller, R. (1994). Microbiology of avian egg. 1st ed. Chapman and Hall. 94: 112–128.

Brooks, G. F., Butel, J. S., Nicholas, Ornston L., Jawetz, E., Melnick, J. L. and Adelberg, E. A. (1995): Jawetz, Melnick & Adelberg's Medical Microbiology (20th ed). Practice-Hall International Inc., 206-217.

California Egg Commission (1999). 2135. Grove Avenue. Suite D Ontario. California 91761.

CDC, National Center for Infectious Diseases (2017) Content source: Centers for Disease Control and Prevention, National Center for Emerging and Zoonotic Infectious Diseases (NCEZID)

Çepoğlu, H., Vatanseve, R. L. and Bilge, O. N. (2010). Isolation of staphylococci from food handlers and investigation of their enterotoxigenicity and susceptibility to some antibiotics. Kafkas University,16, Suppl-A, S1-S5.

Cha, J. O., Lee, J. K., Jung, Y. H., Yoo, J. I., Park, Y. K., Kim, B. S. and Lee Y. S. (2006). Molecular analysis of Staphylococcus aureus isolates associated with staphylococcal food poisoning in South Korea. J. Appl. Microbiol.101:864–871. [PubMed] [Google Scholar].

Cheesbrough, M. (2006). District Laboratory Practice in Tropical Countries (2nd Edition). London English Language Book, Society. 100-194
Dinges, M. M., Orwin, P. M. and Schlievert, P. M. (2000). Exotoxins of Staphylococcus aureus. Clin. Microbiol. Rev. 13: 16–34.

Eid, Samah, Nasef, Soad A. and Erfan, Ahmed M. (2015). Multidrug Resistant Bacterial Pathogens in Eggs Collected From Backyard Chickens. Assiut Vet. Med. J. 61: 144. 87-103.

Elafify, M., Elsherbini, M., Abdelkhalek, A. and Al-Ashmawy, M. (2016). Prevalence and molecular characterization of enteropathogenic Escherichia coli isolated from table eggs in Mansoura, Egypt. J. Adv. Vet. Anim. Res. 3(1): 1-7, ISSN 2311-7710 (Electronic) http://doi.org/10.5455/javar.2016.c123

EL-Kholy, A. M., Hassan, G. M. and Dalia, M. A. (2014). Microbiological Quality of Poultry Farm Table Eggs in Beni-Suef City, Egypt. Assiut Vet. Med. J. 60: 142. 10-13

EL-Leboudy, A. A., El-Shenawy, A. A. and El-Dayash, M. (2011). Criteria for evaluation of eggs and some egg products. Alex.J.Vet.Sci. 34(1):77-88.

EL-Nagar, Shima, Abd El-Azeem M. W., Nasef S. A. and Sultan, S. (2017). Prevalence of toxigenic and Methicillin Resistant Staphylococci in poultry chain production. J. Adv. Vet. Res. 7 (2): 33-38.

ENC, Egg Nutrition Center (2004). Egg protein fact sheet. Emerging Infectious Disease. 4: 667–668.

E.O.S Q.C., Egyptian Organization for Standardization and Quality Control. (2007). No.3169 Fresh table eggs. Egyptian Standards (3169/2007) Table eggs Es. 3169, Ministry of Industry. Cairo. Egypt. Microbiology Notes By Sagar Aryal 2018 by Sagar Aryal© 2019 Microbe Notes.

ESC, Egg Safety Center (2010). Pathogens.http://www.eggsafety.org/consumers/pathogens.

Evêncio-Luz, L., Lima-Filho, J. V. and Evêncio-Neto, J. (2012). Occurrence of Salmonella sp. and coagulase-positive staphylococci in raw eggs and Coalho cheese: comparative study between two cities of Brazil's northeast. Brazilian J. Microbiol. 43(4): 1463-1466. https://dx.doi.org/10.1590/S1517-83822012000400030.

Fardows, J., Siddique, A., Moureen, A., Islam, T., Farhana, N. and Naheen, C. (2016). Isolation and Identification of Pathogenic Gram-Positive Bacteria from Egg Shell of Hen and to See Their Antimicrobial Susceptibility Pattern. Journal of Enam Medical College, 6(1), 15-18. https://doi.org/10.3329/jemc.v6i1.26374

FDA, Food and Drug Administration (2010). New FDA regulation for Salmonella testing in commercial layers. Available from: http://www.vetmed.wsu.edu/deptswaddl/announcements/FDATesting.pdf. Accessed Jul 9, 2010.

Fueyo, J. M., Martin, M. C., Gonzalez-Hevia, M. A. and Mendoza, M. C. (2001). Enterotoxin production and DNA fingerprinting in Staphylococcus aureus isolated from human and food samples, Relations between genetic types and enterotoxins. Int J Food Microbiol 67: 139–145.

Gast, R. K. and Holt, P. S. (2001). Multiplication in egg yolk and survival in egg albumen of Salmonella enterica serotype Enteritidis strains of phage types 4, 8, 13a, and 14b. J. Food Prot., 64, 865–8.

Gantois, I. R., Ducatelle, F., Pasmans, F., Haesebrouck, R., Gast, T., Humphrey, J. and Van Immerseel, F. (2009a). Mechanisms of egg contamination by Salmonella Enteritidis. FEMS Microbiol. Rev. 33: 718–738.
Ghasemian, S., Jalali, M., Hosseini, A.; Narimani, T.; Sharifzadeh, A. and Raheim, E. (2011). The prevalence of bacterial contamination of table eggs from reitails markets by Salmonella spp., Listeria monocytogenes, Campylobacter jejuni and Escherichia coli in Shahrekord, Iran. Jundishapur J. Microbiol. 4(4): 249–253.

Gole, V. C., Chousalkar, K. K. and Roberts, J. R. (2013). Survey of Enterobacteriaceae contamination of table eggs collected from layer flocks in Australia. Int. J. Food Microbiol, 164: 161-165.

Hope, B. K., Baker, R., Edel, E. D., et al. (2002). An overview of the S. enteritidis risk assessment for shell eggs and egg products. Risk Anal. 22: 203–218.

ICMSF, International Committee on Microbiological Specifications for Food. (2009). Microorganisms in food 1. Their Significance and Methods of Enumeration. 2nd Edition. Toronto. Buffalo and London.

Ikeda, T., Tamate, N., Yamaguchi, K. and Makino, S. (2005): Mass outbreak of food poisoning disease caused by small amounts of staphylococcal enterotoxins A and H. Appl. Environ. Microbiol. 71: 2793–2795.

ISO, ISO standard DIS 6888 E. (2003b). Horizontal method for the enumeration of Coagulase Positive Staphylococci (Staphylococcus aureus and other species).

Iyer, A. P. and Kumosani, T. A. (2011). PCR based detection of nosocomial infection causing MRSA (Methicillin resistant Staphylococcus aureus). 2nd International Conference on Biotechnology and Food Science IPCBEE. 7. IACSIT Press, Singapore.

Jay, J. M., Golden, D. A. and Loessner, M. J. (2005). Modern Food Microbiology. (7thed.) ISBN: 978-0-387-23180-8, Publisher: Springer Verlag.

Jones, D. R., Musgrove, M. T. and Northcutt, J. K. (2004). Variation in external and internal microbial populations in shell eggs during extended storage. J. Food Prot. 67: 2657-2660.

Lamaita, H. C., Cerqueira, M. M. O. P., Carmo, L. S., Santos, D. A., Penna, C. F. A. M. and Souza, M. R. (2005). Contagem de Staphylococcus sp. e detecção de enterotoxina estafilococica e toxi A da síndrome do choque tóxico em amostras de leite em refrigerado. Arq. Bras. Med. Vet. Zoot. 57: 702-709.

Lee, M.; Seo, D. J.; Jeon, S. B.; Ok, H. E.; Jung, H.; Choi, C and Chun, H. S. (2016). Detection of Foodborne Pathogens and Mycotoxins in Eggs and Chicken Feeds from Farms to Retail Markets, Korean J. Food Sci. Anim. Resour. 36(4): 463–468.

MAFF, Ministry of Agriculture, Fisheries & Food (2000). Eggs and poultry meat frequently asked question. http://www.maV.gov.uk/foodrin/poultry/epfaq.htm

Mahdavi, M., Jalali, M., Safaei, H. G. and Shamloo, E. (2012). Microbial quality and prevalence of Salmonella and Listeria in eggs. Int. J. Env. Health Eng. 1:48. Available from: http://www.ijehe.org/text.asp?2012/1/1/48/105347

Mansour, A. A., Zayed, A. F. and Basha, O. (2015). Contamination of The Shell and Internal Content of Table Eggs With Some Pathogens During Different Storage Periods. Assiut Vet. Med. J. 61(146):8-15.

Mehrotra, M., WANG, G. and Johnson, W. M. (2000): Multiplex PCR for Detection of Genes for Staphylococcus aureus Enterotoxins, Exfoliative Toxins, Toxic Shock Syndrome Toxin 1, and Methicillin Resistance. J. Clin. Microbiol. 38: 3
Musgrove, M. T., Deana, R. J., Northcutt, J. K., Cox, N. A., and Harrison, M. A. (2004). Identification of Enterobacteriaceae from washed and unwashed commercial shell eggs. J. Food Prot., 67: 2613-2616.

Musgrove, M. T., Jones, D. R., Northcutt, J. K., Cox, N. A. and Harrison, M. A. (2005). Shell rinse and shell crush methods for the recovery of aerobic microorganisms and Enterobacteriaceae from shell eggs. J. Food Prot. 68: 2144-2148.

Musgrove, M. T., Northcutt, J. K., Jones, D. R., Cox, N. A. and Harrison, M. A. (2008). Poult. Sci. J. 87:1211-1218 doi:10.3382/ps.2007-00496.

Obi, C. N. and Igbokwe, A. J. (2007). Microbiological analysis of freshly laid and stored domestic poultry eggs in selected poultry farms in Umuahia, Abia state, Nigeria. Res. J. Biol. Sci. 2: 161-166.

Papadopoulou, C., Dimitriou, D., Levidiotou, S., Gessouli, H., Panagiou, A., Golegou, S. and Antoniades, G. (1997). Bacterial strains isolated from eggs and their resistance to currently used antibiotics: is there a health hazard for consumers? Comp. Immunol. Microbiol. Infect. Dis. 20: 35-40.

Pavani, G. (2012). Drug susceptibility pattern of Klebsiella and Citrobacter infections in India. J. Microbiol. Biotech. Res. 2(4):619- 620.

Pzyzik, E., Marek, A. and Hauschild, T. (2014). Characterisation of Staphylococcus aureus and Staphylococcus aureus – like strains isolated from table eggs. Bull. Vet. Inst. in Pulawy. 58 (1): 57–63

QU, F. Q., Yang, S. Q., Jiu, B., Hang, D. Z., Li, H. W., Liu, S. and Chen, S.Y. (1997). Diagnosis and control of swollen head syndrome in layers. Chinese J. Vet. Medicine. 23(7): 23.

Ricke, S. C., Birkhold, S. G. and Gast, R. K. (2001). Eggs and egg products. In compendium of methods for the microbiological examination of foods. 4th edition. A. P. H. A. Washington. Downes F. P. and Ito K. (eds): 473-479.

Roberts, D.; Hooper, W. and Greenwood, M. (1995). Practical Food Microbiology. 2nd ed. London: Public Health Laboratory Service.

Rodríguez-Lázaro D., Oniciuc, E. A., García, P. G., Gallego, D., Fernández-Natal, I., Domínguez-Gil, M., Eiros-Bouza, J. M., Wagner, M., Nicolau, A. I. and Hernández, M. (2017). Detection and Characterization of Staphylococcus aureus and Methicillin-Resistant S. aureus in Foods Confiscated in EU Borders,Frontiers Microbiol. J. 8:134 https://www.frontiersin.org/article/10.3389/fmicb.2017.01344.

Sabreen, M.S. (2001). Search for some pathogenic bacteria in commercial hens and duck’s eggs sold in Assiut Governorate. Assiut Vet. Med. J.45 (89): 91-103.

Salihu, M. D., Garba, B. and Isah, Y. (2015). Evaluation of microbial contents of table eggs at retail outlets in Sokoto metropolis, Nigeria, Sokoto J. Vet. Sci. 13(1): 22-28.

Schiavoni, L. and Vergora, M. (2000). A symptomatic infections by diarrheagenic Escherichia coli in children from Misiones, Argentina, during the first twenty months of their lives. Rev. Inst. Med. Trop. Sao Paulo. 42(2): 9–15.

Shareef, A. M., Mansour, R. S. and Ibrahim, K. K. (2009). Staphylococcus aureus in commercial breeder layer flocks. Iraqi J. Vet. Sci. 23(I): 63-68.

Siriporn, Chaemsanit, Akbar, A. and Anal, Anil K. (2015). Isolation of total aerobic and pathogenic
bacteria from table eggs and its contents, J. Food Appl. Biosci. 3 (1): 1–9.

Songer, J. G. and Post, K. W. (2005). Detection of Staphylococcus aureus and Streptococcus Agalactiae: Subclinical Mastitis Causes in Dairy Cow and Dairy Buffalo (Bubalus Bubalis). Veterinary Microbiology Bacterial and Fungal Agents of Animal Disease 1st Ed. Elsevier Saunders.

Stepien-Pysniak, D. (2010). Occurrence of Gram-negative bacteria in hens’ eggs depending on their source and storage conditions. Pol. J. Vet. Sci. 13(3): 507-513.

Stepień-Pyśniak, D., Marek, A. and Rzedzicki, J. (2009). Occurrence of bacteria of the genus Staphylococcus in table eggs descended from different sources. Pol J Vet Sci. 2009; 12(4):481-4

USDA, United State Department of Agriculture (2011): Food Safety and Inspection Services. Shell eggs from farm to table. www.fsis.usda.gov, retrieved 12-04-2014.

Wyah, G.M. (1992). Immunoassays for Food Poisoning Bacteria and Bacterial toxins. 1st Ed. Chapman and Hall: 5–13

Yang, S. E., Yu, R. C. and Chou, C. C. (2001). Influence of holding temperature on the growth and survival of Salmonella spp. and Staphylococcus aureus and the production of staphylococcal enterotoxin in egg products, Int. J. Food Microbiol. 63 (1–2): 99-107, https://doi.org/10.1016/S0168-1605(00)00416-5.

Zohair, Ghazi A.M. and Amer, M.M. (2015). A study on bacterial contamination of table eggs sold for consumption in Sana’a city. VMJG. 61 (1): 15–22.ISSN 1110-1423.