Bacterial contamination of hen's table eggs and its influencing by housing systems

K. De Reu[1]*, W. Messens[1], K. Grijspeerdt[1], M. Heyndrickx[1], B. Rodenburg[2], M. Uyttendaele[3], L. Herman[1]

[1]*Institute for Agricultural and Fisheries Research (ILVO), Technology and Food Science Unit, Brusselsesteenweg 370, 9090 Melle, Belgium*
[2]*Animal Breeding and Genomics Centre, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands*
[3] *Department of Food Safety and Food Quality, Laboratory of Food Microbiology and Food Preservation, University of Ghent, Coupure Links 653, 9000 Ghent, Belgium.*

* Corresponding author: Koen.Dereu@ilvo.vlaanderen.be

Abbreviated title: Bacterial egg contamination

Summary

With the introduction of alternative housing systems for laying hens in the EU, recently more research focused on the bacterial contamination of table eggs, e.g. eggshell and egg content contamination. Contamination of eggshells with aerobic bacteria is generally higher for nest eggs from non-cage systems compared to nest eggs from furnished cages or eggs from conventional cages. Studies indicate limited or no systematic differences in eggshell contamination with aerobic bacteria between eggs laid in the nest boxes of furnished cages and eggs laid in conventional cages. The major differences found in experimental studies between cage- and non-cage systems are less pronounced under commercial conditions. The effect of housing system on eggshell contamination with specific groups of bacteria is variable. Limited information is available on the influence of housing system on egg content contamination. Recent research does not indicate large differences in egg content contamination between eggs from cage- and non-cage systems (ignoring outside nest and floor eggs). The microflora of the eggshell is dominated by Gram-positive bacteria, whereas Gram-negative bacteria are best equipped to overcome the antimicrobial defenses of the egg content. Much

of the research on eggshell and egg content contamination focuses on *Salmonella,* since infection with *Salmonella* Enteritidis, resulting from the consumption of contaminated eggs or egg products, is still a major health problem. Observed *Salmonella* prevalence on the eggshell and in the egg content vary, depending on the fact whether investigations were based on randomly sampled table eggs or on eggs from naturally infected hens.

Keywords: bacterial eggshell contamination, egg content contamination, housing systems laying hens, table eggs, food safety

Introduction

The shell can already be infected when passing through the vent, but many researchers suggest that the main bacterial contamination occurs within a short period after laying due to contact with dirty surfaces (Quarles *et al.*, 1970; Gentry and Quarles, 1972). Messens *et al*. (2005) and De Reu *et al*. (2006a; 2006c) reported that increasing numbers of micro-organisms on the eggshell consequently increase the risk of microbial eggshell penetration and egg content contamination. Beside this horizontal route of bacterial infection of eggs, egg contamination also occurs through the vertical or transovarian route. In the transovarian route (vertical transmission), the yolk (very infrequently the yolk itself), the albumen and/or the membranes are directly contaminated as a result of bacterial infection of the reproductive organs.

Global bacterial eggshell contamination

Effect of the housing system

In early studies, bacterial eggshell contamination has been compared in litter and wire floor houses. Quarles *et al.* (1970) reported that litter floor houses had on average 9 times more bacteria in the air, and 20 to 30 times more aerobic bacteria on the shell than wire floor houses. Harry (1963) reported that the shells of eggs from deep litter systems had 15 times more bacteria and a higher proportion of potential spoilage organisms than eggs from battery cage systems.

Conventional cage housing for laying hens will be prohibited from 2012 in the European Union, following EU-directive 1999/74. From 2012 onwards, only furnished cages and non-cage systems (aviaries and floor housing) will be allowed. For the first time in many years, more attention was given to effect of housing system on the bacterial eggshell contamination of table eggs.

Conventional and furnished cages

De Reu *et al*. (2005b) compared the bacterial eggshell contamination of eggs laid in conventional cages with eggs laid in the nest boxes of furnished cages. No systematic difference in contamination with total count of aerobic bacteria was found between these systems (4.0 - 4.5 log CFU/eggshell). Also, for Gram-negative bacteria no difference was detected (circa 3.0 log CFU/eggshell). The type of nest-floor material in the nest boxes of the furnished cages also did not systematically influence the bacterial eggshell contamination. Cepero *et al*. (2000; 2001) also found no differences in counts of aerobic mesophilic bacteria but reported a higher prevalence of coliforms on shells of eggs laid in furnished cages. Mallet *et al*. (2006) studied the hygienic aspects of eggs laid at different locations in furnished cages. A significant difference in total count of aerobic bacteria was observed on the eggshell of eggs collected from furnished cages (4.83 log CFU/eggshell) compared to conventional cages (4.56 log CFU/eggshell). This was mainly due to the eggs laid outside the nest in the litter area (4.96 log CFU/eggshell) or in the cage (4.94 log CFU/eggshell). The bacterial load on eggs laid in the nests was similar to those collected from the conventional cages. Similar conclusions were obtained for *Enterococcus.* Wall *et al*. (2008) also found a higher bacterial load on eggs from furnished cages compared to conventional cages. The bacterial counts were significantly ($P<0.001$) higher in the furnished cages compared to the conventional cages as regards *Enterococcus* and total number of aerobic bacteria.

Cage- and non-cage systems

In further experimental studies, it was found that eggs from aviaries were more contaminated with aerobic bacteria than eggs from cage systems (Protais *et al.*, 2003a; De Reu *et al.*, 2005b). The difference was more than 1 log unit (up to 5.1 – 6.0 log CFU/eggshell for eggs from aviaries), with much higher counts on those eggs laid on the floor of the aviaries (up to 7 log CFU/eggshell). For Gram-negative bacteria no systematic differences were found between cage and non-cage housing systems (De Reu *et al.*, 2005b).

Experimental studies compared to on farm studies

De Reu *et al*. (2005a; 2006b) also evaluated whether the differences in initial eggshell contamination, found in the experimental housing systems, were also applicable to commercial conventional cage and non-cage housing systems. Two conventional cage systems, one organic aviary system and one floor housing system were included. On average, a higher (P<0.001) initial eggshell contamination with total count of aerobic bacteria was found for eggs from non-cage systems compared to conventional cage systems; respectively 5.46 compared to 5.08 log CFU/eggshell. However, initial contamination with total count of Gram-negative bacteria on the eggshells was significantly lower (P<0.001) in the non-cage systems; 3.31 compared to 3.85 log CFU/eggshell. This study showed that the major differences in eggshell contamination with total count of aerobic bacteria, found between conventional and non-cage systems in the experimental studies (>1 log) were less pronounced in the sampled commercial housing systems. The even lower initial contamination with Gram-negative bacteria in the commercial non-cage systems was remarkable.

International on-farm studies

Six flocks of laying hens in furnished cages and seven flocks in non-cage systems (3 aviaries and 4 floor systems) were compared in the international study of De Reu *et al.* (2007b). On average, eggshells from furnished cages were slightly, but significantly (P<0.001), less contaminated with total count of aerobic bacteria compared to non-cage eggshells (4.75 versus 4.98 log CFU/eggshell). In the non-cage systems, no difference in average contamination between aviary and floor systems was found. Both, within furnished cage- and within non-cage systems, major differences between farms were obtained. Differences in farm management can explain this. For Enterobacteriaceae no significant difference in average eggshell contamination was found between furnished and non-cage systems.

Bacterial air contamination and its relationship with eggshell contamination

In some studies the total count of aerobic bacteria in the air of poultry houses has been found to be positively correlated with the initial bacterial eggshell contamination at the henhouse (Protais *et al.*, 2003a; De Reu *et al.*, 2005b). Averages of 4 log CFU/m^3 air for the conventional and furnished cages were found compared with a 100 times higher average (> 6 log CFU/m^3) for aviary housing systems.

Influence of housing system on quality of eggs and egg products

At this moment, it remains unknown whether the differences in bacterial counts on the shell of eggs produced in different housing systems have an impact on the quality of eggs and egg products. Harry (1963), De Reu *et al.* (2006a; 2006c) and many other researchers found a correlation between bacterial eggshell contamination and egg infection or egg content contamination. The higher prevalence of coliforms on the shells of eggs laid in furnished cages was not correlated with signs of coliform contamination in egg yolk or albumen (Cepero *et al.*, 2000; Cepero *et al.*, 2001). In a preliminary study of De Reu *et al.* (2007a; 2007b), egg content contamination of nest eggs was 1.9% (5/269 eggs) for furnished cages compared to 2.3% (10/432 eggs) for non-cage systems.

Salmonella contamination of eggs

Little research is done on the influence of housing system on eggshell and egg content contamination with *Salmonella.* A study of the UK Food Standards Agency in 2003 did not find significant differences in *Salmonella* spp. contamination on the shell due to the production system (Anon., 2004b). On a total of 4753 retail samples of boxes with six eggs, the eggshell of 9 samples was contaminated. None of the 4753 pooled egg contents of retail samples were *Salmonella* positive.

Conclusions

It is clear that eggshell contamination with aerobic bacteria is on average significantly higher for nest eggs from non-cage systems compared to nest eggs from furnished cages or eggs from conventional cages. The major differences found in experimental studies between cage and non-cage systems are less pronounced under commercial circumstances. The little information available on the influence of the housing systems on the egg content contamination indicate no large differences in egg content contamination between cage eggs and non-cage eggs (ignoring outside nest and floor eggs).

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