

Bacteriological contamination of eggs and eggshell quality in furnished cages and non-cage systems for laying hens: an international on-farm comparison

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Materials and methods

Farms

13 flocks of laying hens on 10 farms were included in this study. Six flocks were housed in furnished cages (FC) and seven in non-cage systems. Of these seven flocks, three were housed in aviaries (A) and four in floor housing systems (FH). Only farms without an outdoor run were included. Regarding the farms with furnished cages, only farms were included with fully equipped furnished cages (perches, nest, scratching area). The farms were visited and sampled when the birds were about 60 weeks of age. Farms from three different countries were included in the study (Belgium, The Netherlands and Germany). On each farm eggs were sampled at the egg belts (no ground eggs).

Sampling, collection and transport of eggs

To produce statistically reliable results 40 and 120 eggs were sampled at each farm; respectively for the determination of the bacterial eggshell contamination and for the determination of the proportion of dirty, broken and hair-cracked eggs (3). The eggs were sampled by hand, placed in open carton filler-flats and brought by car, in ambient conditions, to the laboratory where they were kept for maximum 56 h. in ambient conditions before analysing (3).

Determination of bacterial eggshell contamination

For the recuperation or recovery of bacteria from the eggshell, the intact egg was placed in a plastic bag with 10 ml quarter-strength Ringer's solution (Oxoid, Hampshire, UK) and the egg was rubbed through the bag for 1 minute (3). The diluent was plated on Nutrient Agar (Oxoid) for the determination of the total counts of aerobic bacteria and on Violet Red Bile Glucose Agar (Oxoid) for the enumeration of *Enterobacteriaceae*. Plates were incubated respectively for 3 and 1 day(s) at 30°C.

Visual examination of the eggs

Each egg was thoroughly evaluated visually and placed into one of the following four categories: feces and/or blood, egg white and/or egg yolk, dust and/or feathers and total dirty eggs (1). Also the occurrence of cracks (open or closed) and micro-cracks (2) in the eggshell was noted. The visual examination of the eggshell was performed using a candling light.

Egg content contamination

To remove the egg content aseptically the eggshell was first disinfected with hydrogen peroxide (30%) followed by short flaming with alcohol. The disinfected egg was broken by hand (with sanitized plastic gloves) using a sterile blade and the egg content was enriched in BPW (Oxoid) at 30°C for 24h and plated out on Nutrient Agar. Plates were incubated at 30°C for 72h. (5)

Environmental conditions at the farm

An Air Sampler RCS (Biotest AG, Dreieich, Germany) was used to determine total bacterial count and *Enterobacteriaceae* per m³ air of the hen-house. Strips in the air sampler contained Nutrient Agar (Oxoid) and Violet Red Bile Glucose Agar (Oxoid) respectively. Strips were incubated respectively for 3 and 1 day(s) at 30°C.

Statistical analysis of data

The bacterial counts were log-transformed prior to statistical analysis (6). Significant differences were assessed using an analysis of variance (ANOVA), done in Statistica 7.0 (Statsoft Inc., Tulsa, USA). The underlying assumptions for an ANOVA were verified: the homogeneity of variances and the absence of a correlation between means and variances was checked on a plot. Post-hoc inter factor differences were calculated using Duncan's test (7).

Results and discussion

Bacteriological eggshell contamination

Figure 1a shows the individual results for the eggshell contamination with total count of aerobic bacteria for the different sampled furnished cages and figure 1b for the different sampled non-cage systems. Figures show that both, within furnished cages and within non-cage systems, major significant differences were obtained. Within the six furnished cages differences in average eggshell contamination ranged from 4.24 - 5.22 log cfu/eggshell ($P < 0.001$). Comparable average differences were observed for the seven non-cage systems ($P < 0.001$, range 4.35 - 5.51 log cfu/eggshell).

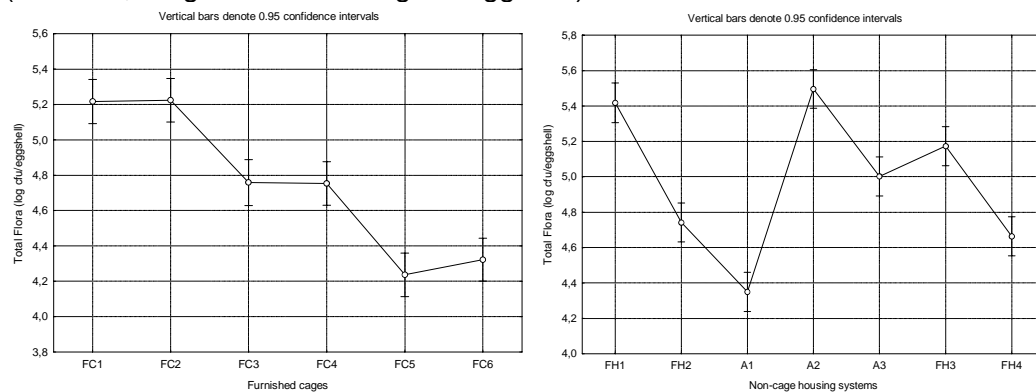


Figure 1a and 1b: Average eggshell contamination (n=40 eggs) with total count of aerobic bacteria in the individual furnished cages (FC) and the individual non-cage systems (FH = Floor housing; A = Aviary)

Figure 2a shows that the average eggshell contamination with total count of aerobic bacteria found in the four floor housing systems (5.00 log cfu/eggshell) was not significantly different ($P > 0.05$) from the average contamination in the three aviary systems (4.95 log cfu/eggshell). On the other hand a significant difference ($P < 0.001$) was found between the average eggshell contamination for eggs from all non-cage systems compared to all furnished cages (Figure 2b). Eggshells from furnished cages were less contaminated with total count of aerobic bacteria compared to non-cage eggshells (4.75 versus 4.98 log cfu/eggshell).

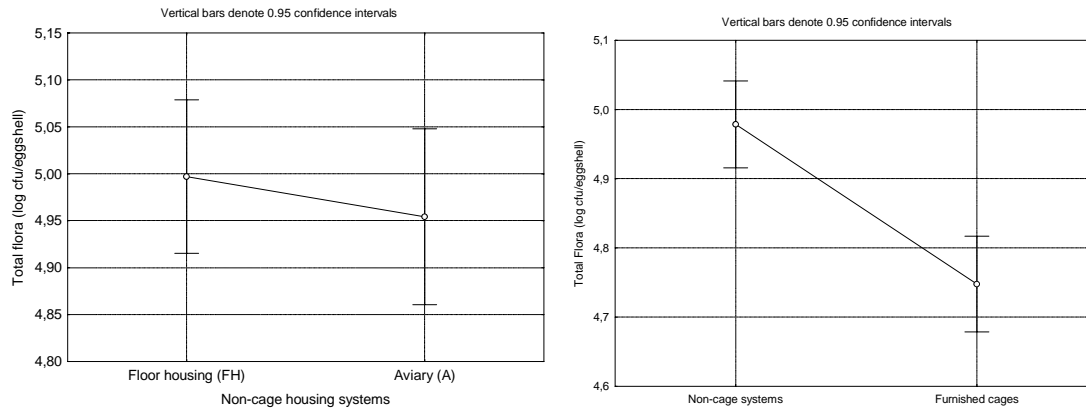


Figure 2a and 2b: Average eggshell contamination with total count of aerobic bacteria in the two types of non-cage housings systems (FH = Floor housing; A = Aviary) and in the non-cage systems compared to the furnished cages

Table 1: Counts of *Enterobacteriaceae* on the eggshell for the different housing systems

	n	<10 cfu/eggshell	>10 cfu/eggshell	
			Average log	Stdev. log
Floor housing	157	93%	1,62	0,88
Aviary	121	96%	1,37	0,41
<i>Non-cage housing</i>	<i>278</i>	<i>94%</i>	<i>1,54</i>	<i>0,76</i>
<i>Furnished cages</i>	<i>230</i>	<i>88%</i>	<i>1,51</i>	<i>0,63</i>

For *Enterobacteriaceae* no significant difference in average eggshell contamination was found between furnished and non-cage systems. Respectively 88% and 94% of eggshells contained <10 CFU *Enterobacteriaceae*/eggshell (see table 1).

Egg content contamination in relation to the housing system

Egg content contamination was 1,9% (5/269 eggs) for furnished cages compared to 2,3% (10/432 eggs) for non-cage systems. Although only a limited number of eggs was tested, these preliminary results indicate no significant difference in egg content contamination between both systems.

Bacteriological air contamination

The average bacteriological contamination of the air with total count of aerobic bacteria was significant higher for non-cage systems (5,31 log cfu/m³) compared to furnished cages (4,75 log cfu/m³). On the other hand air contamination with *Enterobacteriaceae* was lower (not significant) in non-cage systems (0.72 log cfu/m³) compared to furnished cages (1.35 log cfu/m³).

Visual examination of the eggs

The total percentage of broken and hair-cracked eggs was higher ($P<0.05$) in the furnished cages (7,8%) compared to the non-cage systems (4,1%). This was due to the high percentage (24%) observed on one of the furnished cage farms. No significant difference in number of dirty eggs was found between furnished cages and non-cage systems. Within the non-cage systems, no differences were found for broken and hair-cracked eggs as well as for dirty eggs between aviary and floor housing.

Conclusions

We conclude that the bacteriological contamination of eggs and the eggshell quality differed substantially between individual farms using the same housing system. Consequently, comparisons of housing systems based on a limited number of farms ought to be interpreted with caution. This may also explain some discrepancies between the findings of the present

study versus some findings of previous pilot or experimental studies on a very small number of farms (8; 4). We found that average differences in bacteriological contamination of eggs and eggshell quality between both housing systems were rather limited. In our study only eggs sampled at the egg belts were included.

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