The eggshell quality of table eggs and how this affects food safety

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Abbreviations

ABS	Australian bureau of statistics
AECL	Australian egg corporation limited
BPW	buffered peptone water
BSN	breaking shell strength
CC	conventional cage production system
cfu	colony forming unit
CO_2	carbon dioxide
EDTA	ethylenediaminetetraacetic acid
FR	free range production system
g	gram
HCl	hydrochloric acid
hr	hour
IgY	Immunoglobulin Y
M	molar
mm	millimeter
mM	millimolar
µL	micro litre
µm	micrometer
nm	nanometer

N	Newtons
PBS	phosphate buffered saline
PP IX	protoporphyrin IX
RVS	rappaport –vissiliadis soya peptone broth
RO	reverse osmosis
rpm	rotation per minute
Sec	second
SE	standard error
SEM	scanning electron microscope
TBC	total bacterial count
TEC	total Enterobacteriaceae count
TSI	triple sugar iron
TSS	technical services and supplies
VBRGA	violet red bile glucose agar
wk	week
XLD	xylose lysine deoxycholate

Abstract

The longitudinal effect of age and production system was evaluated for egg quality parameters and egg microbial load by following 2 flocks (Hy Line brown commercial layer), one conventional cage production system (CC) and one free range (FR). A horizontal study of the effect of flock age (22, 39, 55 and 79 wk) of the same strain of bird from the same CC was also evaluated for egg quality parameters and egg microbial load. From the CC and FR production systems, eggs were collected at the age of 25, 35, 45, 55, 65 and 75 wk with one extra collection at 85 wk from CC. For the eggshell and egg internal quality parameters, a significant main effect ($P<0.05$) of flock age and production system or interaction between the two was recorded for egg translucency, shell reflectivity (%), egg weight (g), shell weight (g), percentage shell, shell thickness (μm), albumen height (mm), Haugh unit and yolk colour. Breaking shell strength (BSN) and shell deformation (μm) were only significantly affected by flock age and interaction between flock age and production system. In the horizontal study, all eggshell and egg internal quality variables were significantly affected by flock age.

The amount of cuticle quantified by spectrophotometry and scanning electron microscopy (SEM) of stained eggs was higher in the middle of the lay versus early and late lay and was significantly higher for CC compared to FR eggs. Similarly, the cuticle cover was higher in mid lay period in the horizontal study.

Shell mammillary layer ultrastructural variables that have a positive effect on the shell decreased in incidence with increasing flock age while the incidence of negatively affecting variables tended to increase being higher in FR. Similarly, in the horizontal study, variables having a positive effect decreased with flock age and the incidence of the negative variables tended to increase.

The overall bacterial load on the eggs was low in the present study, as compared with other published studies. The total bacterial count (TBC) and total Enterobacteriaceae count (TEC) on the eggshells and in shell crush changed significantly with flock age, being higher in the mid lay period. The overall bacterial load was higher for FR versus CC eggs. The egg internal contents were negative for bacteria in both CC and FR eggs. Two egg belt swabs from FR were positive for *Salmonella* Infantis while *Salmonella* was not recovered from CC swabs.

Protoporphyrin IX (PP IX) quantified from the cuticle and true eggshell at flock ages of 33, 50 and 67 wk was higher in the true eggshell than in the cuticle and was not significantly affected by flock age. PP IX in the cuticle, as a percentage of total PP IX in the shell with cuticle was 13% in 33 wk, 20 % in 50 wk and 18 % in 67 wk eggs. The L*a*b components of the colour space system and shell reflectivity (%) were significantly different ($P<0.0001$) among the age groups.

In the whole egg penetration studies, *Salmonella* Infantis was recovered only from shell rinsate of 1 pooled sample (2 eggs) while none of the egg internal contents were positive for *Salmonella* Infantis suggesting that the Infantis serovar may be more vulnerable to the antimicrobial properties of albumen. In the agar egg moulding technique, all the washed eggs were penetrated and70% penetration occurred in the unwashed eggs. There was a positive correlation between egg translucency and *Salmonella* penetration in both washed and unwashed groups. A lower amount of cuticle was also recorded in the penetrated areas.