Egg quality testing and identification of quality risk factors

A report for the Australian Egg Corporation Limited

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and Kapil Chousalkar

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Foreword

This project was conducted to provide on-going egg quality testing for the AECL as part of an overall quality assurance program. The project aimed to provide a “snapshot” of egg quality in the Australian industry at a particular point in time and to identify risk factors associated with losses in egg quality (internal quality and egg shell quality). Where major egg quality problems were identified, the project planned to conduct a detailed analysis of all possible causes. A total of 210 flocks were sampled from most states of Australia: NSW 67, VIC 54, QLD 55, SA 20, WA 14). Eggs were sampled on-site for egg weight and albumen height from which Haugh Units were calculated. A second sample of eggs from each flock was despatched to the egg quality laboratory for detailed analyses. A questionnaire was completed for all farms from which eggs were sampled.

This project was funded from industry revenue which is matched by funds provided by the Federal Government.

This report is an addition to AECL’s range of research publications and forms part of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

Most of our publications are available for viewing or downloading through our website:

www.aecl.org

Printed copies can be purchased by faxing or emailing the downloadable order form from the website or by phoning (02) 9409 6999

Angus Crossan
Research Manager
Australian Egg Corporation Limited

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Ms Mandy Tyack, Golden Egg Farms

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Australian Egg Corporation Limited funded the project.

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Kapil Chousalkar has recently commenced a new job as a Lecturer B in the Faculty of Science, School of Animal and Veterinary Sciences, Charles Sturt University, Wagga Wagga. During this project, he was a Postdoctoral Fellow in Animal Science, School of Environmental and Rural Science at the University of New England. His research interests include avian virology, food safety and egg quality.

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Executive Summary

The egg is the final product of the Australian Egg Industry and its internal and external quality are of paramount importance to the industry and the consumer. Quality Assurance programs are an essential feature of all egg producing establishments. A comprehensive data base of egg quality measurements (from almost 25,000 eggs) was assembled during the project UNE 71A which resulted in the 2004 AECL publication “Egg Quality Guidelines for the Australian Egg Industry”. The current project conducted further egg quality testing to enable the continuing development of a database of egg internal quality and egg shell quality within the Australian Egg Industry. A particular emphasis of the current project was to identify egg quality risk factors, where problems with egg quality were identified.

In recent years, there have been some acute problems with poor albumen quality. Therefore, the current project specifically targeted albumen quality of freshly-laid eggs taken straight from the cage front and compared these results with those obtained during later laboratory testing.

Where major problems with egg quality were identified, the intention was to conduct detailed testing of all possible contributors would have been conducted to attempt to identify the cause(s). However, this proved unnecessary as all flocks sampled were within expected range for the age of each flock and no one flock warranted detailed investigation.

Overall Conclusions

In general, egg shell quality and egg internal quality were relatively independent of state, strain of bird and egg production system although there was a range of values for all parameters measured. When flocks from different states were compared, several free range flocks from SA had lighter coloured shells, some QLD flocks had higher shell deformation and shell thickness and some NSW flocks were significantly below average for shell thickness. When the three strains of bird were compared, there were some differences. Albumen height of freshly measured eggs was generally highest for HyLine and lowest for HiSex although much of this could be explained by differing egg weights and there was less variation among strains for Haugh Unit. A small number of flocks, including three free range flocks, had lighter coloured shells. The cause of this reduced pigmentation is not known although suggestions include anaemia (Juergen Lohr, personal communication). The two barn flocks that had very low yolk colour appear not to have had pigment added to the feed. There were relatively few differences among production systems. As expected, albumen height and Haugh Unit measured later in the laboratory were generally lower than those measured directly at the cage front. However, watery whites were encountered only rarely and not consistently throughout a flock. This finding suggests that there is not a major problem with water albumen in Australian layer flocks. Comparison of the results of the 2009 study with those obtained in 2003 reveal some general differences with egg weight being lower, egg shell colour darker, shell deformation lower and shell thickness higher in the 2009 study.

The extent of variability within a flock varied from relatively low for egg weight to relatively high for shell breaking strength and shell deformation. The findings of this study have been compared against arbitrary standards for some variables. However, again, there is considerable variation amongst flocks of similar ages.

Overall, the results indicate that there are no major problems with egg shell quality and egg internal quality in Australian layer flocks. However, they do show that there is a range of values occurring from flocks at any given age. This suggests that some producers are towards the upper end of what is possible in the commercial industry whereas others have the potential for improved performance.

Egg shell quality and egg internal quality are known to be influenced by a wide range of factors (see Roberts, 2004 and Roberts, 2008) including strain of bird, age of bird, nutrition including protein source, moult status, water quality, general stress, heat stress, disease, housing, production system, environmental contaminants and use of proprietary products. In most situations where egg quality is sub-optimal, the cause will be multifactorial. Occasionally, a single major cause will be identified. Therefore, the key to improvements in egg quality lies in attention to each and every stage of the production process – from the hatchery right through the laying cycle.

1. General Introduction

The egg is the final product of the Australian Egg Industry and its internal and external quality are of paramount importance to the industry and the consumer. Quality Assurance programs are an essential feature of all egg producing establishments. A comprehensive data base of egg quality measurements (from almost 25,000 eggs) was assembled during the project UNE 71A which resulted in the 2003 AECL publication "Egg Quality Guidelines for the Australian Egg Industry". The current project conducted further egg quality testing to enable the continuing development of a data base of egg internal quality and egg shell quality within the Australian Egg Industry. In recent years, there have been some acute problems with poor albumen quality. The current project specifically targeted albumen quality of freshly-laid eggs taken straight from the cage front.

Australian per capita consumption of eggs (approximately 196) is about one third of egg consumption in the USA and Canada. Therefore, the potential exists for a substantial increase in egg consumption in Australia, particularly now that the AECL has been successful in achieving the Heart Foundation's Tick of Approval for eggs.

Losses of eggs owing to poor shell quality have been conservatively estimated at 10%. For the Australian industry (13 million hens x 27 dozen eggs; $1.6/dozen farm gate) each 1% loss in saleable eggs is approximately $5 million annually. A loss in consumer purchase equal to 1% (1.5 eggs x 25 million persons = 3.1 million dozen x $1.6 @ farm gate) is also a loss of $5 million / yr. However, losses in saleable eggs would also include the input costs (pullet, feed) associated with producing that egg (analysis by Scott, 2006).

The outcomes of this project benefit producers by providing an updated database of egg quality measurements against which their own performance can be compared.

Consumers benefit by the application of the research to provide eggs of reliably high quality.

2. General Materials and Methods

2.1 General Methodology

The project involved egg quality testing from a range of poultry establishments for the purposes of updating the existing AECL egg quality database and identifying risk factors. Research and industry contacts in most states of Australia (see contact persons listed below) sampled eggs, 30 per flock, directly from the cage front for measurement of albumen quality. A sample of 90 eggs from the same source was sent by courier to the University of New England where they were subjected to the full range of egg quality tests: shell colour, shell breaking strength and deformation, shell weight, shell thickness, albumen height, Haugh Units, yolk colour score. Routine sampling was conducted across a range of flock ages, including early, mid and late lay.

The following people collected data for the study:

Mr. Peter Bell, Altona Hatchery Pty Ltd, 344 Hawtin Rd, Forrestfield, WA 6058, Email: p.bell@altona.net.au; Ms Mandy Tyack, Golden Egg Farms, 43 Mc Gregor Rd, Palmyra WA 6157, Email: mtyack@goldeneggs.com.au (WA)

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Some people who had originally intended to participate were unable to do so because of changed circumstances.

For each site, a detailed questionnaire was completed (see Appendix 1).

Sampling was largely opportunistic, depending on which producers agreed to participate in the study and were geographically accessible to the project sampling team. The funding available for the study was not sufficient to allow a full epidemiological study. It was essential that participants utilised their sampling time efficiently by visiting a number of flocks on each visit and/or that they conducted sampling when they were already visiting flocks for other purposes.

Once this report has been accepted by AECL, the egg analysis results will be sent to the participating producers in the form of a full report explaining the significance of the results and comparing the results from each producer against the data base.

If a problem with egg quality had been identified, detailed sampling was to be undertaken immediately for water quality testing, detailed feed analysis, blood samples for antibody testing, sacrificing of birds for histological testing (if indicated), bird body weight, samples of excreta and feathers, air quality testing. However, there proved to be no need to conduct such analyses. The budget had allowed for two detailed samplings to be conducted and there were no flocks which clearly justified this activity.

2.2 Egg Quality Analyses

2.2.1 Measurements taken on-farm

For the specific purposes of the project, replicate sets of portable albumen quality testing equipment were ordered from Technical Services and Supplies (TSS), U.K. (see Photograph 2.1). This equipment was easily transported into the field so that measurements of egg weight and albumen height (from which Haugh Unit could then be calculated) could be made directly at the cage front. For each flock, 30 eggs were assessed on-farm. An additional 90 eggs were packaged up and sent to the University of New England. The only exception to this arrangement was the laboratory analyses on 28 of the flocks from Queensland which were analysed on the same TSS equipment as that at the University of New England.

egg weight (Ohaus Portable balance) Egg weight is the weight of the egg in grams.

albumen height (TSS portable automatic Haugh Unit gauge). Albumen height is the height that the albumen or white of the egg stands up when an egg is broken out onto a flat surface. The TSS equipment measures the albumen height via a probe which detects, electrically, when the surface of the albumen is reached.

Haugh Units (read off from the chart provided by TSS from egg weight and albumen height). Haugh Units are calculated from albumen height and egg weight by the formula developed by Haugh in 1937. The Haugh Unit takes into account the size of the egg. Albumen height and Haugh Units are used as an indicator of internal egg quality or freshness. The equation for calculation of Haugh Units is:

$$H.U. = 100LOG\left[H - \frac{\sqrt{G}(30W^{0.37} - 100)}{100} + 1.9\right]$$

H.U. = Haugh units

H = albumen height in mm

G = 32.2

W = weight of whole egg in grams

Photograph 2.1 TSS Portable albumen quality equipment

2.2.2 Measurements conducted in the laboratory

A full range of egg quality measurements was conducted in the Egg Laboratory at the University of New England, using the equipment shown in Photograph 2.2

2.2.2.1 Egg Internal quality measurements

albumen height (TSS automatic Haugh Unit gauge). Albumen height is the height that the albumen or white of the egg stands up when an egg is broken out onto a flat surface. The TSS equipment measures the albumen height via a probe which detects, electrically, when the surface of the albumen is reached.

Haugh Units (calculated by the TSS software from egg weight and albumen height). Haugh Units are calculated from albumen height and egg weight by the formula developed by Haugh in 1937. The Haugh Unit takes into account the size of the egg. Albumen height and Haugh Units are used as an indicator of internal egg quality or freshness. The equation for calculation of Haugh Units is as outlined above.

yolk colour score (TSS automatic yolk colorimeter). Yolk colour is determined on the Roche Scale. The TSS yolk colorimeter measures the colour by measuring the wavelength of light reflected from the yolk. There is no user-error associated with this measurement.

2.2.2.2 Egg shell quality measurements

egg weight (TSS equipment balance) Egg weight is the weight of the egg in grams.

shell colour (measured by TSS reflectivity meter). Shell reflectivity, expressed as a percentage, is the amount of light that is reflected from the surface of an egg. It is an indication of shell colour lightness – the higher the value, the lighter the colour of the egg shell.

shell breaking strength (measured by quasi-static compression using TSS equipment). Shell breaking strength, in Newtons, is the force which must be applied to the egg before it fails.

deformation (TSS shell breaking strength machine). Deformation is the distance in micrometres that the egg is depressed by the egg shell breaking strength machine before the egg fails. It is an indicator of the elasticity of the egg shell.

shell weight (TSS equipment balance). Shell weight is the weight, in grams, of the shell which has been carefully washed out and dried.

shell thickness (UNE shell thickness gauge). Shell thickness is measured in micrometres, using a custom-built gauge, based on a Mitutoyo Dial Comparator Gauge.

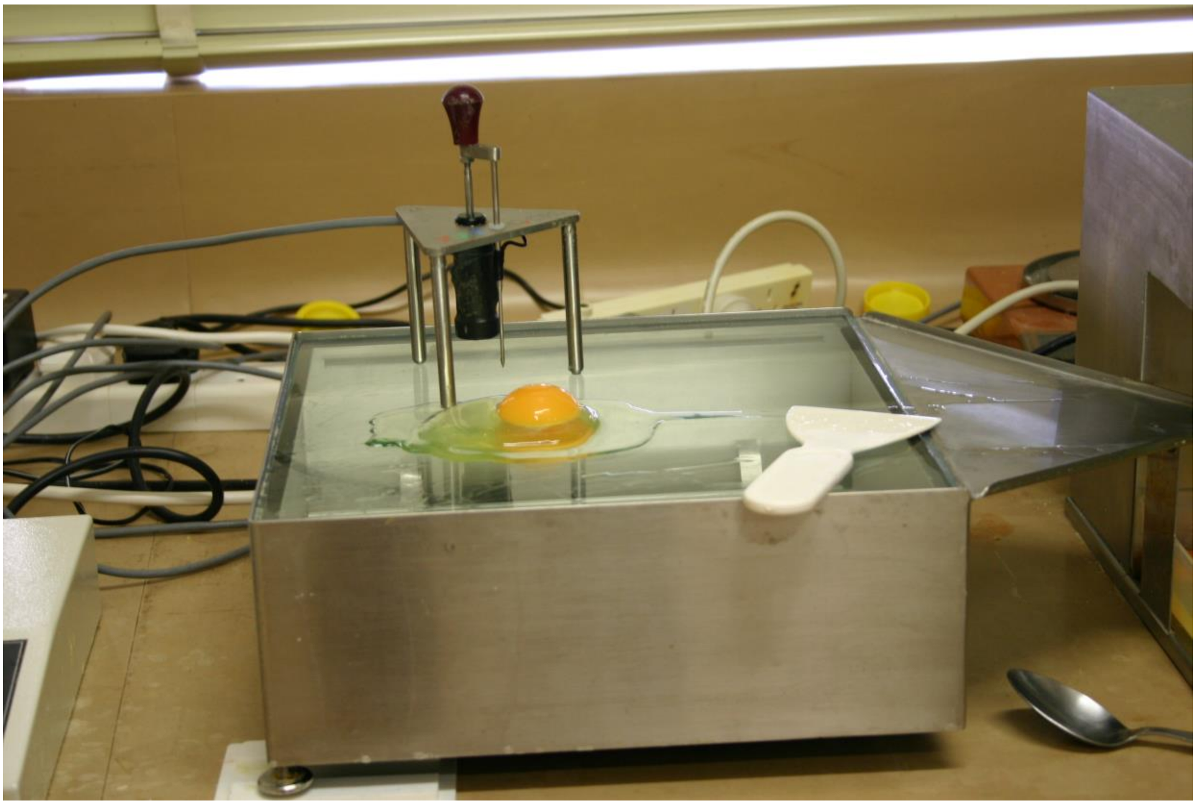
shell weight : egg weight ratio (calculated). This ratio is also called the percentage shell and is shell weight divided by egg weight, multiplied by 100 to obtain a percentage.

Photograph 2.2 The full set of TSS equipment for measuring egg quality

Photograph 2.3 The TSS equipment for measuring shell reflectivity and egg weight

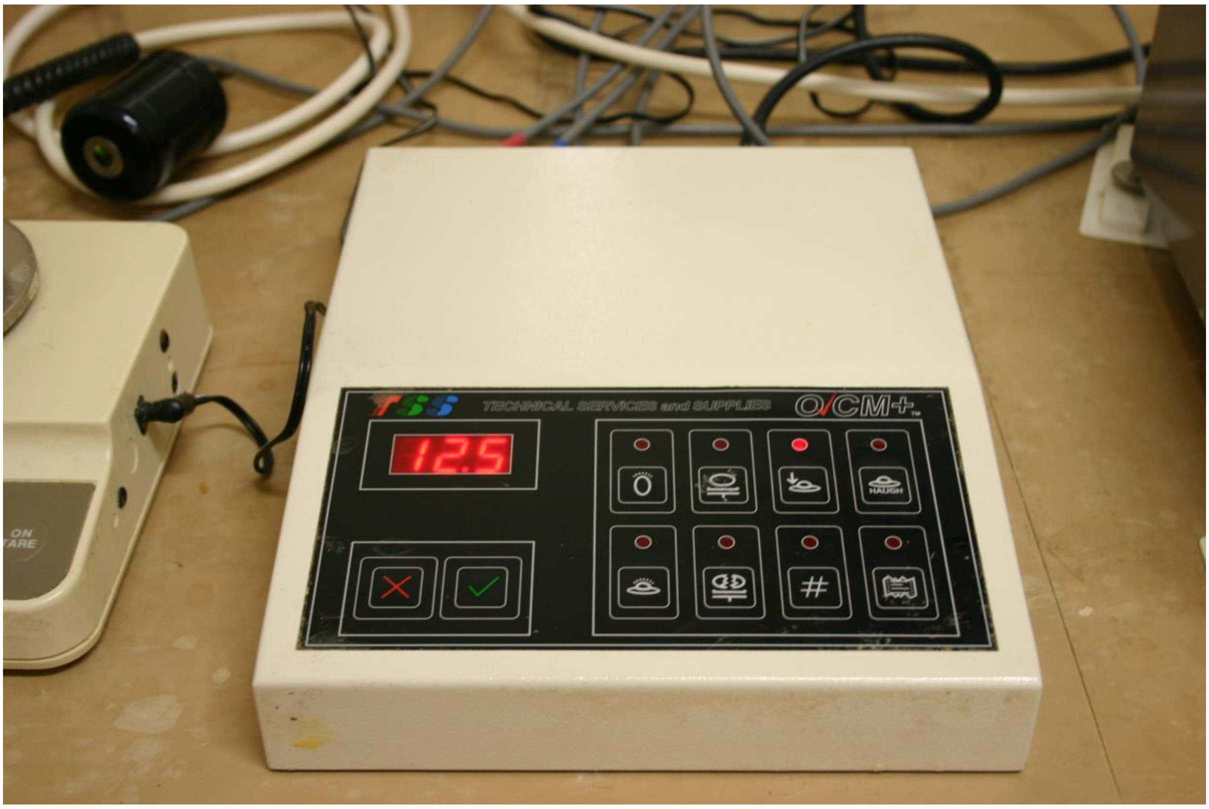
Photograph 2.4 TSS Equipment for measuring shell breaking strength

Photograph 2.5 TSS Equipment for measuring albumen height



Photograph 2.6 TSS Equipment for measuring yolk colour

Photograph 2.7 The microprocessor that coordinates the input from the TSS equipment



Photograph 2.8 Equipment for measuring egg shell thickness

3. RESULTS

3.1 Characteristics of Flocks Sampled

Table 3.1.1: Ages of Flocks

Category	Age in weeks	Number of Flocks
Early Lay (E)	<25-30	38
Early – Mid Lay (E-M)	31-44	52
Mid Lay (M)	45-50	32
Mid – Late Lay (M-L)	51-59	38
Late Lay (L)	60-65	12
Later in Lay (L+)	>65	38

A total of 6300 eggs were analysed on-site for egg weight, albumen height and Haugh Units. In addition, a total of 18,039 eggs were analysed in the laboratory for the full range of egg shell quality and egg internal quality measurements.

Samples collected by state and production system are shown in Table 3.1.2.

Table 3.1.2: Flocks by State and Production System

State	All Samples	Cage	Free Range	Barn
NSW	67	52	15	0
VIC	54	34	13	7
QLD	55	49	5	1
SA	20	9	11	0
WA	14	12	2	0
TOTAL	210	156	46	8

Figure 3.1 Number of flocks sampled by production system

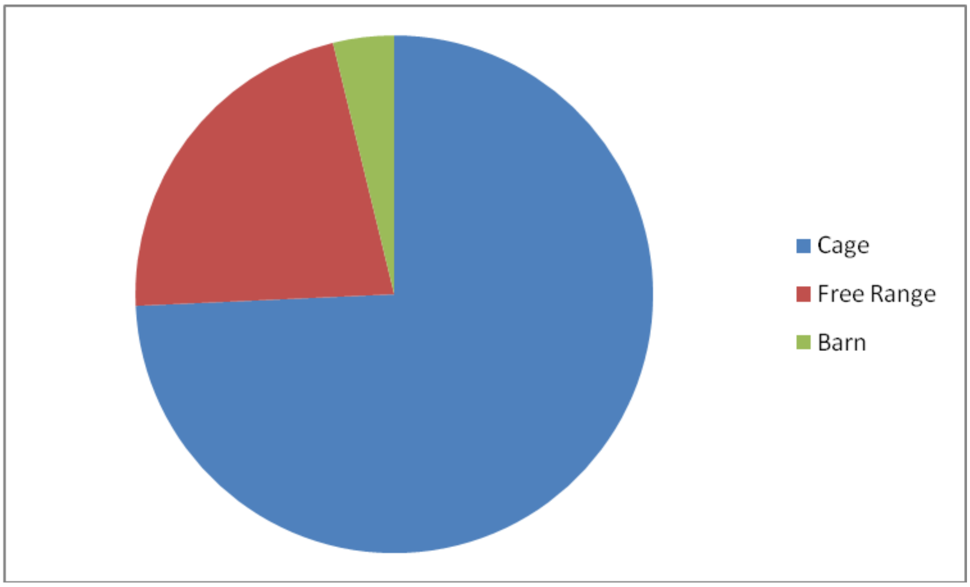


Figure 3.2 Average Flock Size by Production System

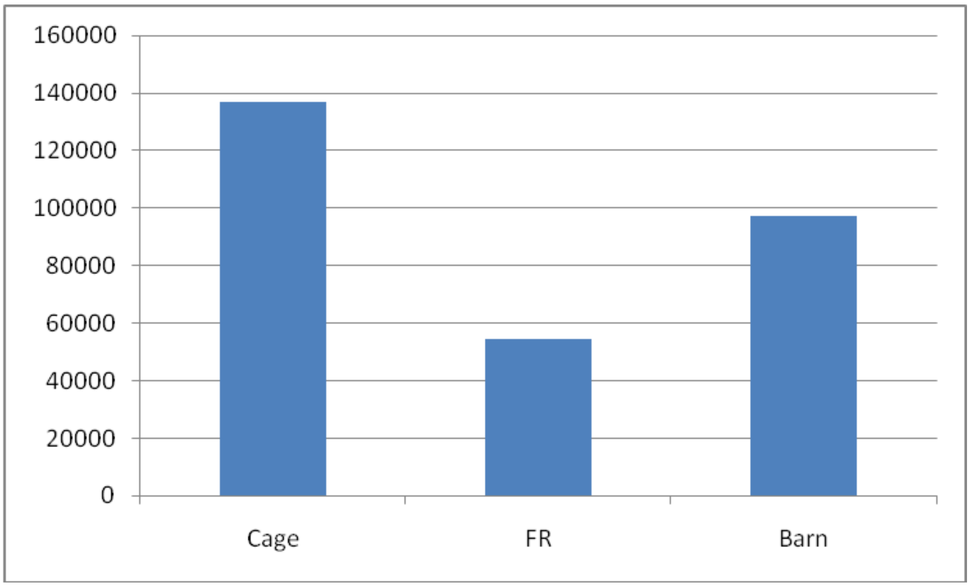


Table 3.1.3: Flocks by State and Strain

State	ISA	HyLine	HiSex
NSW	33	17	17
VIC	10	22	22
QLD	9	44	2
SA	0	17	3
WA	0	14	0
TOTAL	52	114	44

Table 3.1.4: Flocks by Production System and Ages in Shed

Ages in Shed	ALL	Cage	Free Range	Barn
Single Age	165	108	48	6
Multi Age	44	44	0	0

Table 3.1.5: Flocks by Water Source

Source	No. Flocks	Treatment
Town/Reticulated	93	Nil
Bore	78	Chlorination 18 Filtration + Chlorination 7 None 18 Reverse Osmosis 13 Reverse Osmosis + Chlorination 4 Not Specified 18
Dam	29	Chlorination 12 Filtration + Chlorination 7 Iodine 3 None/Not Specified 11
River/Scheme	6	Filtered + Chlorinated
Channel	4	Filtered + Chlorinated

Table 3.1.6: Flocks by production system, ages in shed and ventilation type
N is natural ventilation; C is controlled ventilation

Ages in Shed	Ventilation	Cage	Free Range	Barn	ALL
Single	N	20	49	2	71
	C	88	3	4	95
Multi	N	37	0	0	37
	C	7	0	0	7
TOTAL		152	52	6	210

Table 3.1.7 Average Years of Staff Experience by Production System

Cage	Free Range	Barn
22 (<1 to >50)	16 (<1 to 40)	23 (<1 to 60)

Table 3.1.8 Storage Temperature of eggs (°C) by production system

	Cage	Free Range	Barn
Temperature	14 (9-17)	14 (10-16)	14 (11-17)
Relative Humidity	83 (75-89)	83 (80-86)	80

Table 3.1.9 Frequency of Egg Collection (%) by Production System

	Cage	Free Range	Barn
Daily	71%	66%	83%
6 days per week	17%	-	17%
Twice Daily	7%	25%	-
More than Twice Daily	2%	9%	-
Less than 6 days	3%	-	-

Table 3.1.10 IB Vaccination Protocols

	Frequency of Revacc	Cage	Free Range	Barn
During Rear Only (no. of times)		76% of flocks (85% 3 times, 9% 4 times 3% 5 times 3% once)	55% of flocks (87% 3 times, 8% once, 8% 5 times)	50% of flocks
During Rearing and also during lay		24% of flocks	45% of flocks	50% of flocks
	Every 2 wks	-	10%	-
	Every 6 wks	50%	50%	50%
	Every 7 wks	10%	-	-
	Every 8 wks	20%	30%	50%
	Every 10 wks	20%	10%	-

Table 3.1.11 Auditing of flocks

Audit	Cage	Free Range	Barn
	67% Yes 33% No	78% Yes 22% No	50% Yes 50% No
ECA	56%	64%	75%
Safe Food QLD	18%	8%	25%
Other	26%	28%	-

Table 3.1.12 Types of fillers used by production system

	Cage	Free Range	Barn
Cardboard	73%	59%	50%
Plastic	7%	31%	50%
Cardboard & Plastic	11%	10%	
In-Line	9%	-	-

Table 3.1.13 Evidence of IB Infection by production system

	Cage	Free Range	Barn
Respiratory Illness	9% Yes 91% No	3% Yes 97% No	40% Yes 60% No
IB Diagnosis (by titre)	3% Yes 97% No	Nil Yes All No	20% Yes 80% No

Ca splashes were reported only in older flocks from all production systems

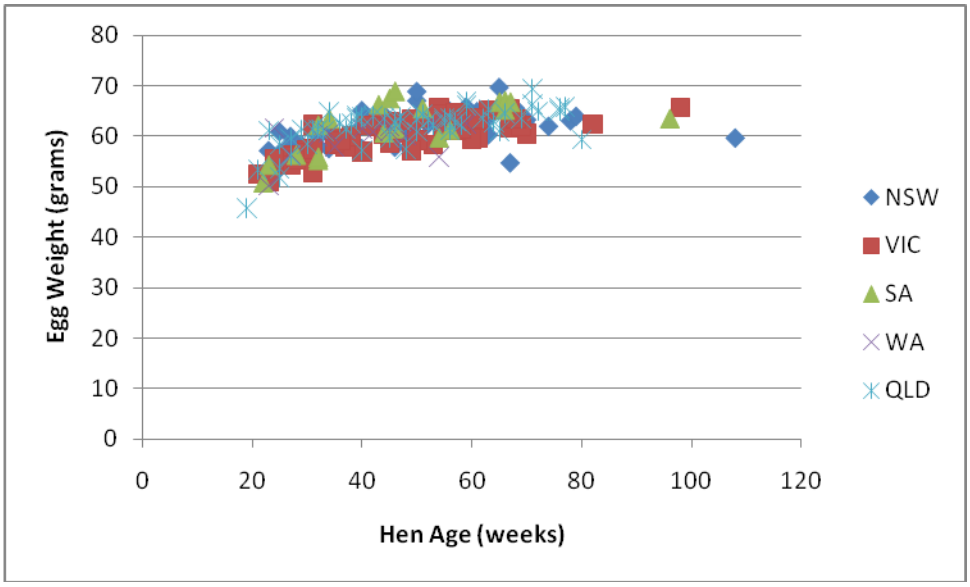
Table 3.1.14 Age (weeks) of first egg, peak production and 90% production by production system

	Cage	Free Range	Barn
Age at 1st egg	17.5	17.5	17.5
Age at peak production	28.7	30	27
Age at 90% Production	51	44	55

3.2 Egg Quality Data by State

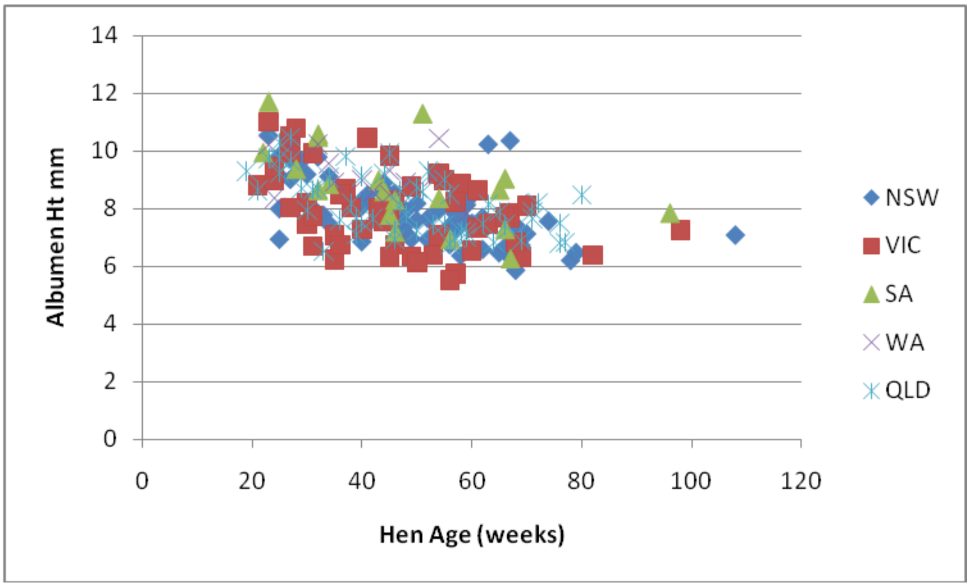
3.2.1 On Farm Egg Quality

Figure 3.2.1.1 Egg Weight (grams) versus hen age by state



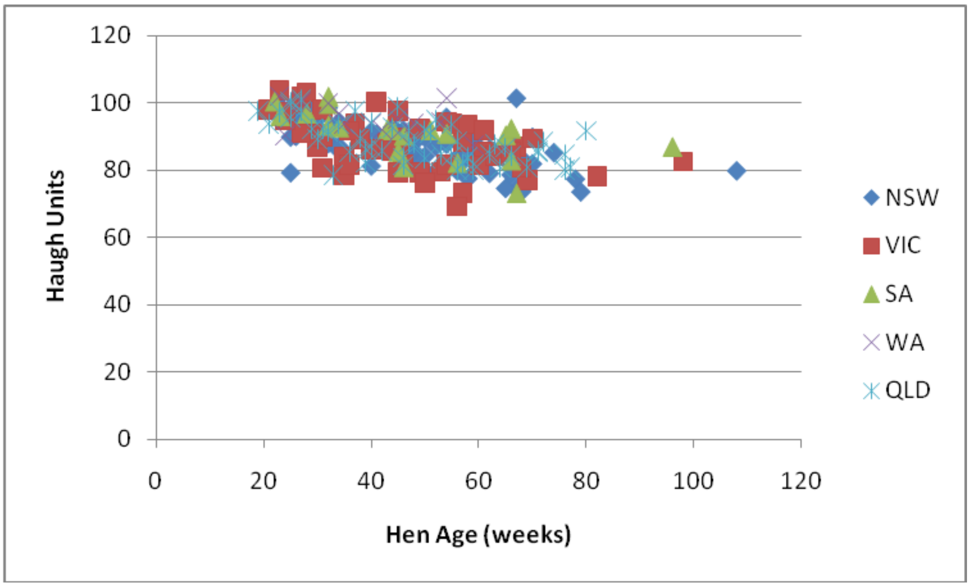
Egg weight increased from 20 weeks of hen age and generally plateaued at a level between 60 and 70 grams. There was no difference among states.

Figure 3.2.1.2 Albumen Height (mm) versus hen age by state



Albumen height decreased with hen age. There was no overall difference among states.

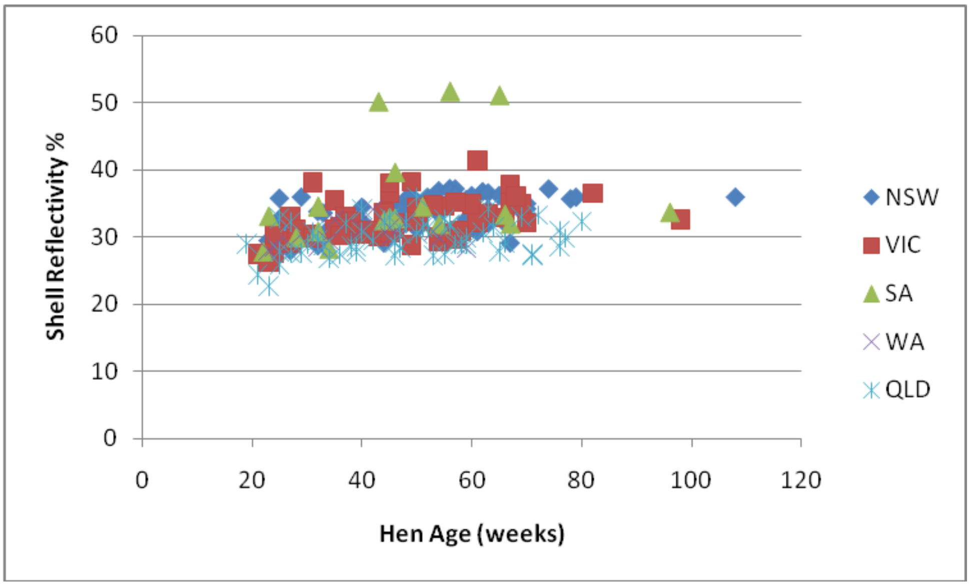
Figure 3.2.1.3 Haugh Unit versus hen age by state



Haugh Unit decreased with hen age. There was no overall difference among states.

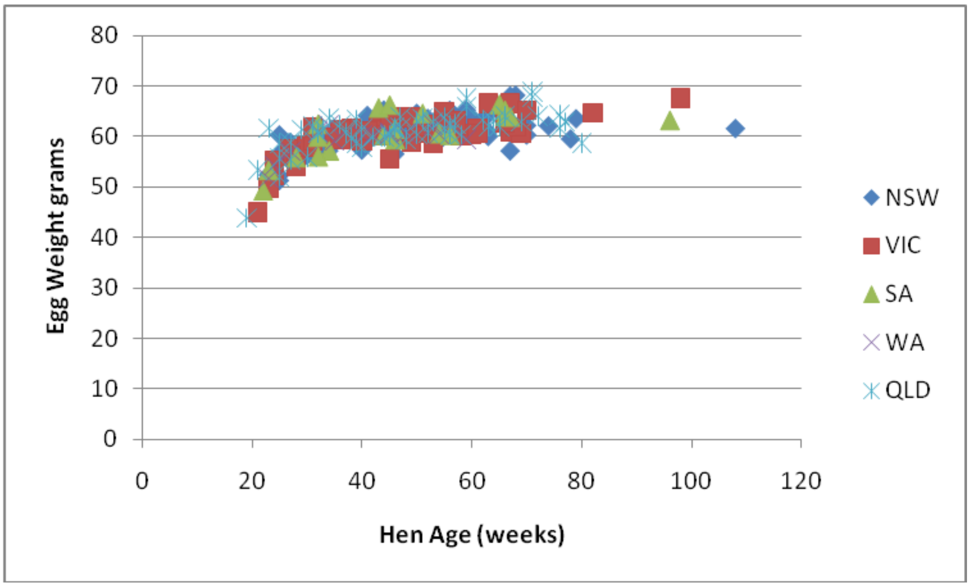
3.2.2 Laboratory Analyses of Egg Quality

Figure 3.2.2.1 Shell Reflectivity (%) versus hen age by state



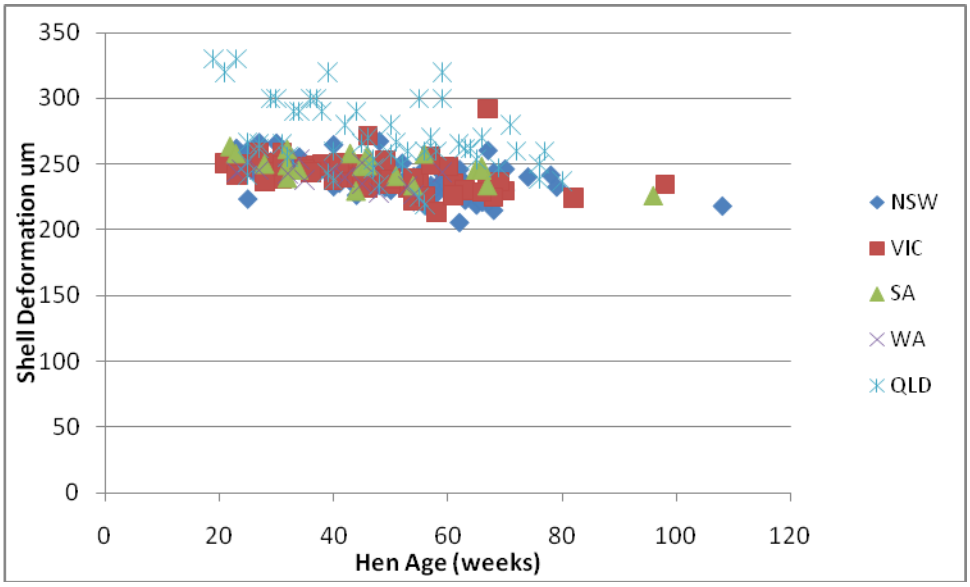
Shell reflectivity increased with hen age initially but then remained relatively stable. Three free range flocks from SA had significantly higher shell reflectivity.

Figure 3.2.2.2 Egg Weight (grams) versus hen age by state



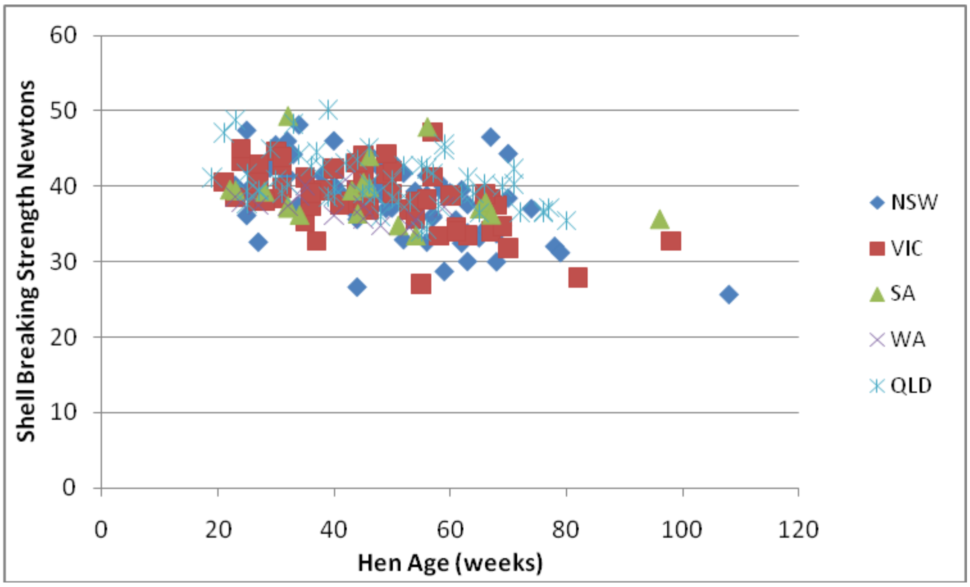
Egg weight increased with hen age and there were no differences among states.

Figure 3.2.2.3 Shell Deformation (μm) versus hen age by state



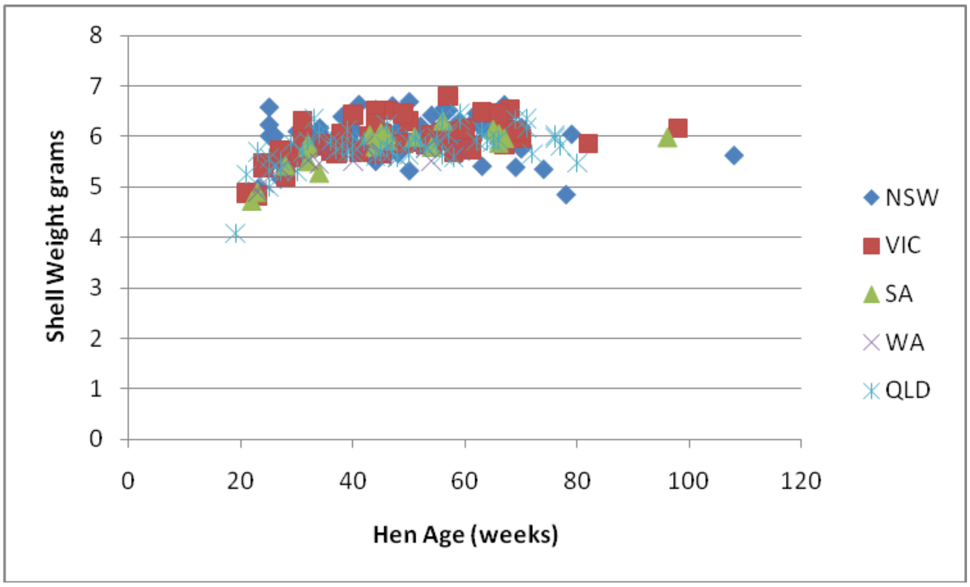
Shell deformation generally decreased with hen age. The higher values for some flocks from QLD may be related to different laboratory technique in the QDPI&F laboratory. The placement of the egg in the holder and the distance between the top surface of the egg and the breaking strength machine can influence this measurement. If an egg rotates as it is being compressed, the shell deformation value can be artificially high.

Figure 3.2.2.4 Shell Breaking Strength (Newtons) versus hen age by state



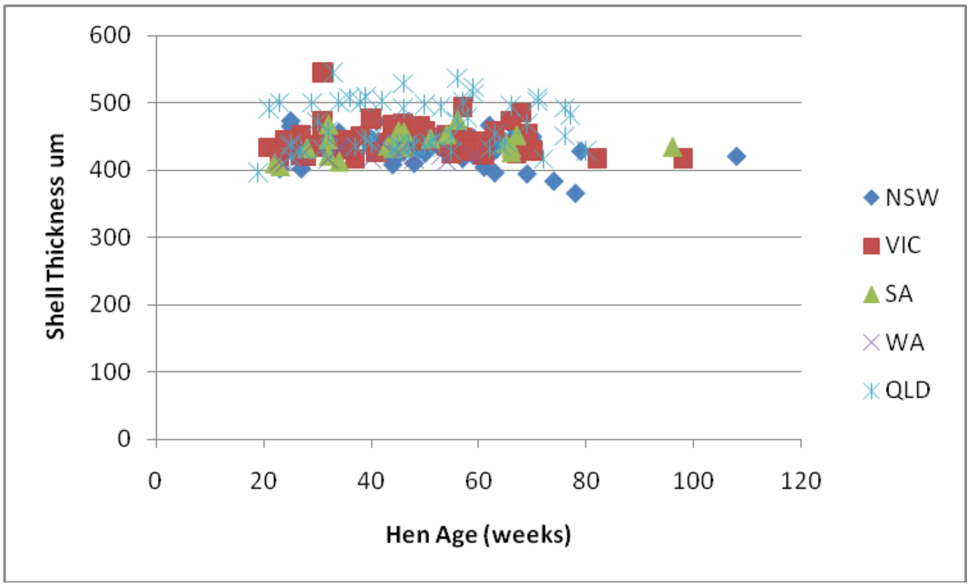
Shell breaking strength decreased with hen age and, although there was range of values, there was no clear difference among states.

Figure 3.2.2.5 Shell Weight (grams) versus hen age by state



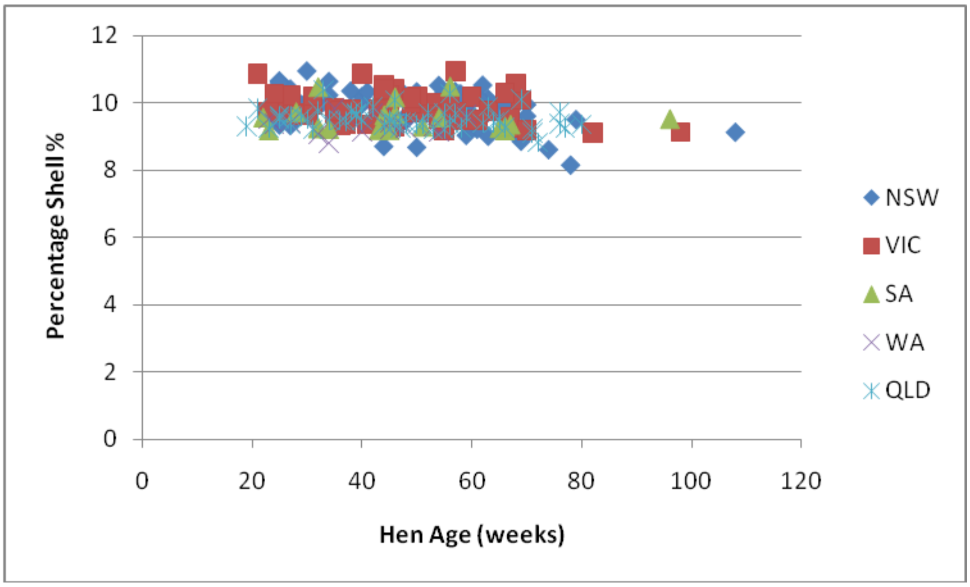
Shell weight generally increased in a manner similar to egg weight. There were no consistent differences among states although some states in NSW were lower than average.

Figure 3.2.2.6 Shell Thickness (μm) versus hen age by state



Shell thickness was relatively stable across a range of hen ages and there was no clear difference among states. The higher values for some of the QLD flocks may be associated with different laboratory practice. If shells are not dried completely or if the shell thickness gauge does not allow for the curvature of the egg shell, artificially high values may be obtained. In addition, some flocks from NSW were below average.

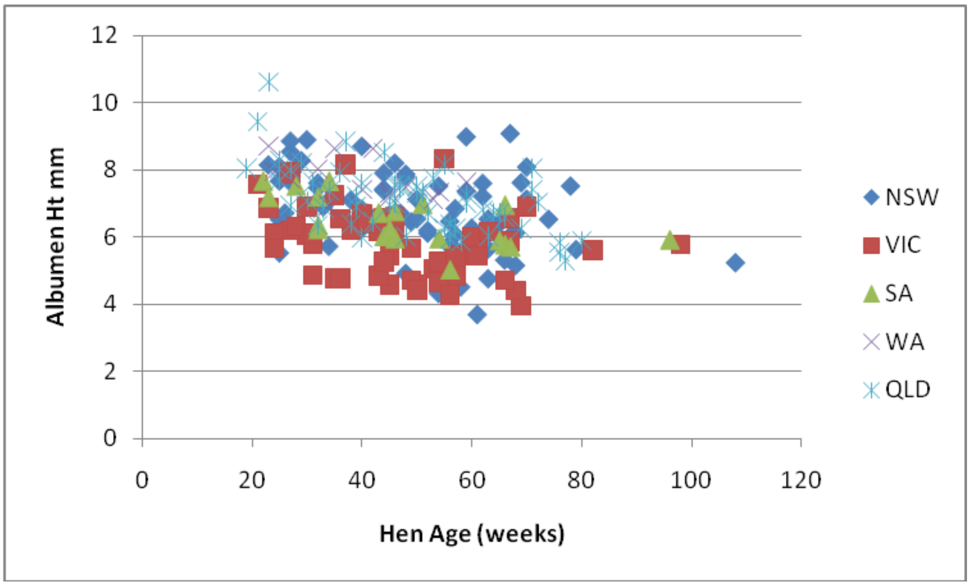
Figure 3.2.2.7 Percentage Shell (%) versus hen age by state



Percentage shell was relatively constant until 70 weeks of age after which it tended to decrease. There was no consistent difference among states.

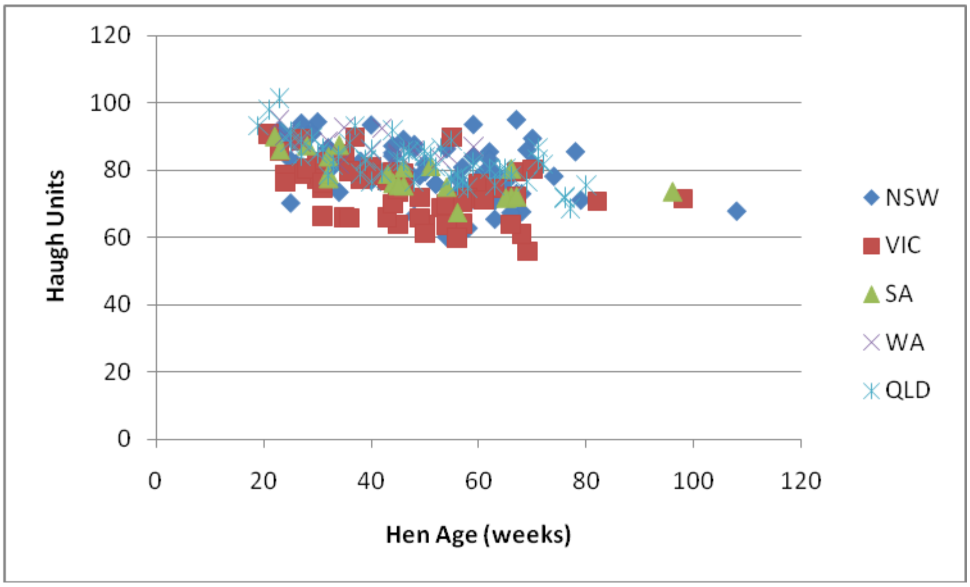
Egg Internal Quality

Figure 3.2.2.8 Albumen Height (mm) versus hen age by state



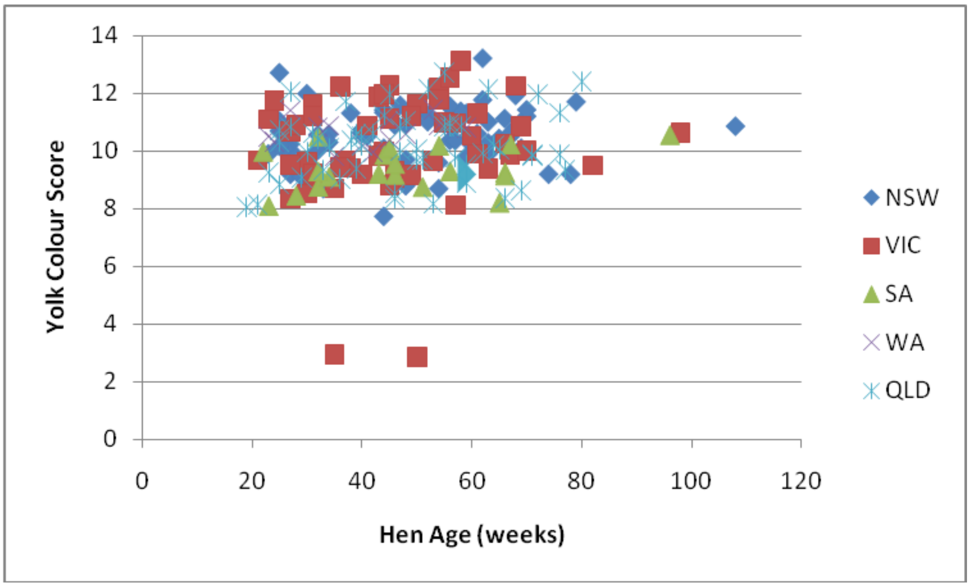
Albumen height, as measured in the laboratory varied to a much greater extent than for eggs measured at the cage front, owing to varying lengths of time elapsing between egg collection and measurement (see also Figure 3.6.1.3). Overall, albumen height decreased with hen age.

Figure 3.2.2.9 Haugh Unit versus hen age by state



Haugh Unit, as measured in the laboratory varied to a much greater extent than for eggs measured at the cage front, owing to varying lengths of time elapsing between egg collection and measurement (see also Figure 3.6.1.3). Overall, Haugh unit decreased with hen age.

Figure 3.2.2.10 Yolk Colour Score versus hen age by state

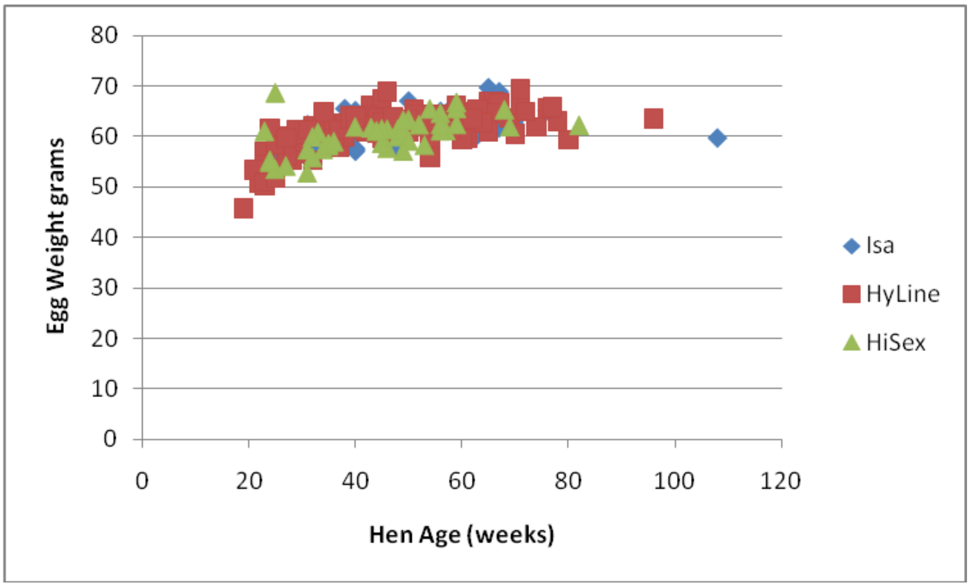


Yolk colour varied between 8 and 13 and was independent of hen age and state. Two barn flocks from VIC were well below the average.

3.3 Egg Quality Data by Strain of Bird

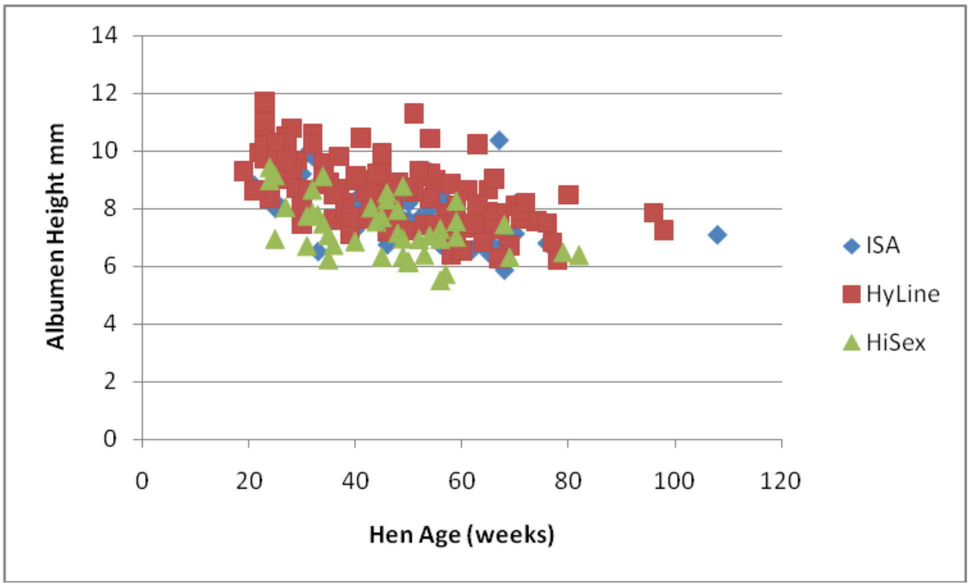
3.3.1 On Farm Egg Quality by Strain

Figure 3.3.1.1 On Farm Egg Weight (grams) versus hen age by strain



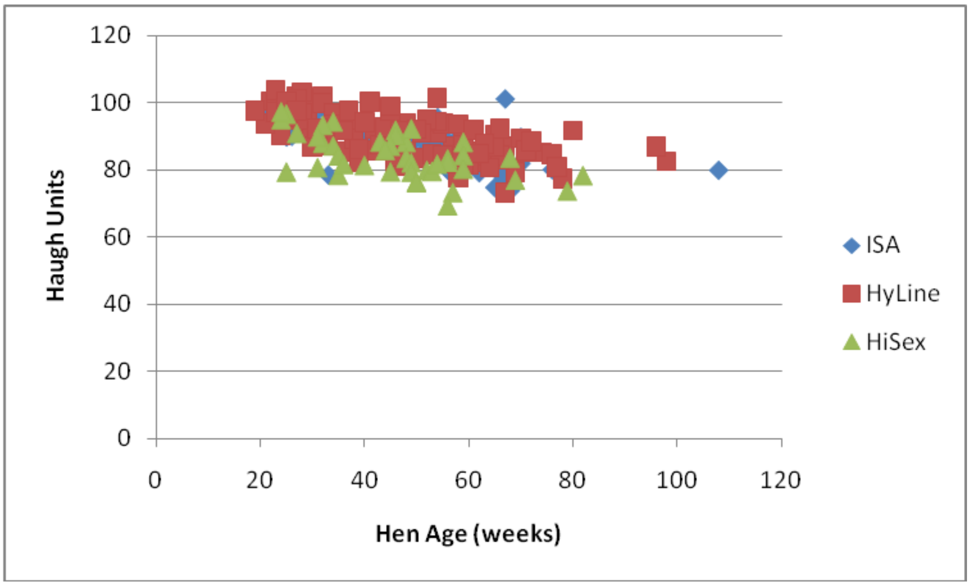
The relationship between egg weight and hen age was similar for all strains.

Figure 3.3.1.2 On Farm Albumen Height versus hen age by strain



Albumen height measured on freshly collected eggs declined with hen age. Albumen height was generally highest for the HyLine Brown and lowest for the HiSex birds.

Figure 3.3.1.3 On Farm Haugh Unit versus hen age by strain

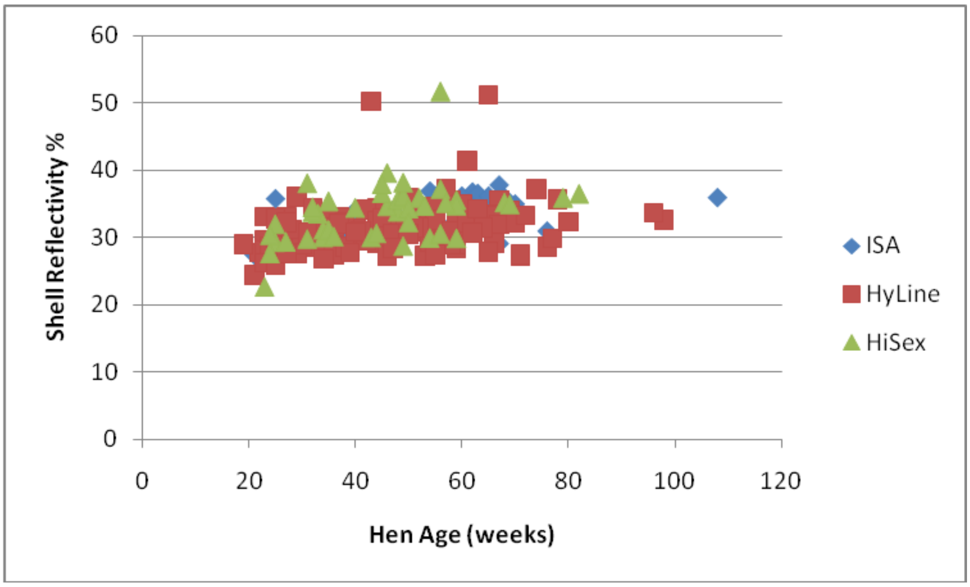


Haugh Unit measured on freshly collected eggs declined with hen age. Haugh Unit, which takes into account the size of the egg, was more similar among strains of bird than albumen height.

3.3.2 Laboratory Analyses of Egg Quality by Strain

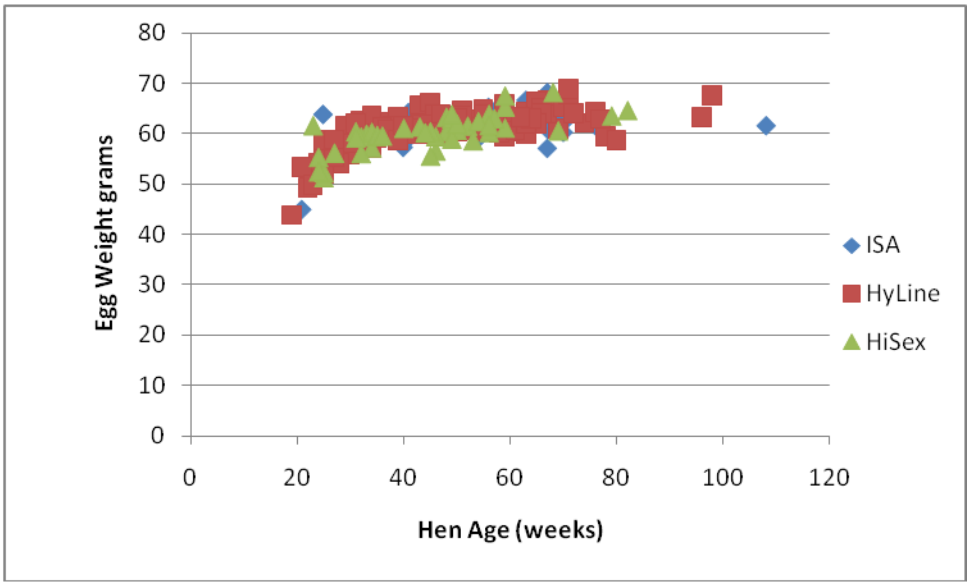
3.3.2.1 Egg Shell Quality

Figure 3.3.2.1 Shell Reflectivity (%) versus hen age by strain



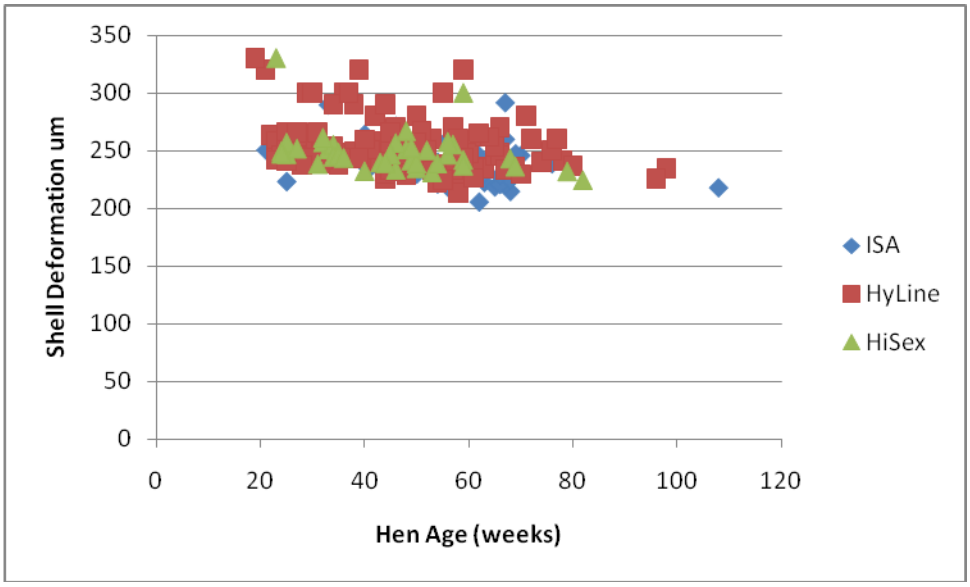
There was considerable overlap among strains for shell reflectivity. Three free range flocks, two HyLine and one HiSex had significantly lighter shell colour.

Figure 3.3.2.2 Egg Weight (grams) versus hen age by strain



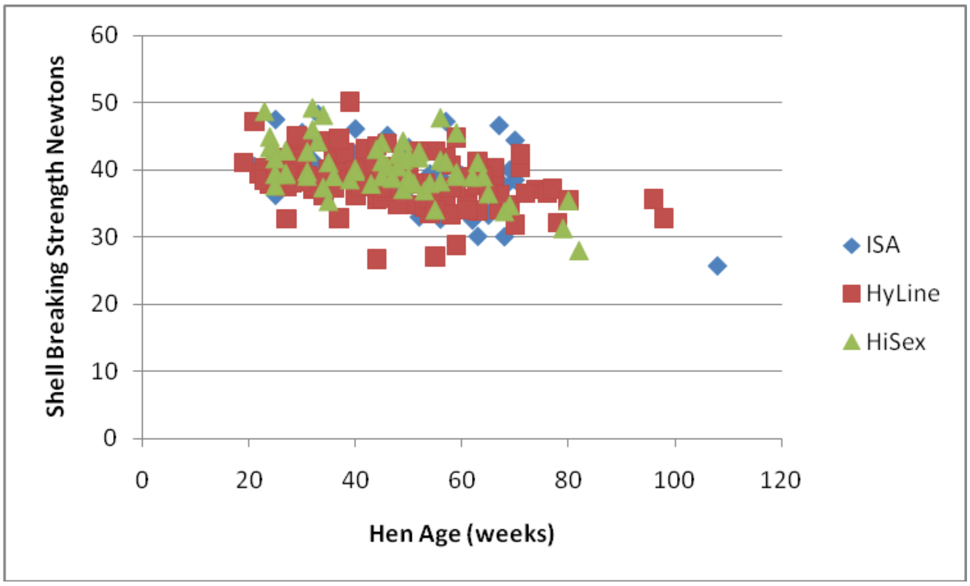
Egg weight measured in the laboratory increased with hen age and was not different among strains

Figure 3.3.2.3 Egg Shell Deformation (μm) versus hen age by strain



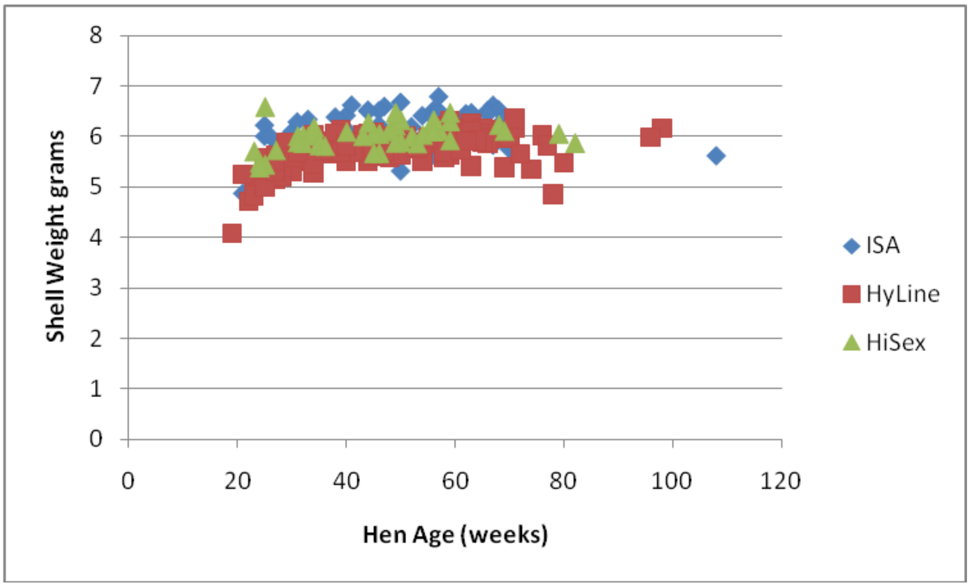
Shell deformation generally decreased with hen age. The higher values for some flocks from QLD may be related to different laboratory technique in the QDPI&F laboratory.

Figure 3.3.2.4 Shell Breaking Strength (Newtons) versus hen age by strain



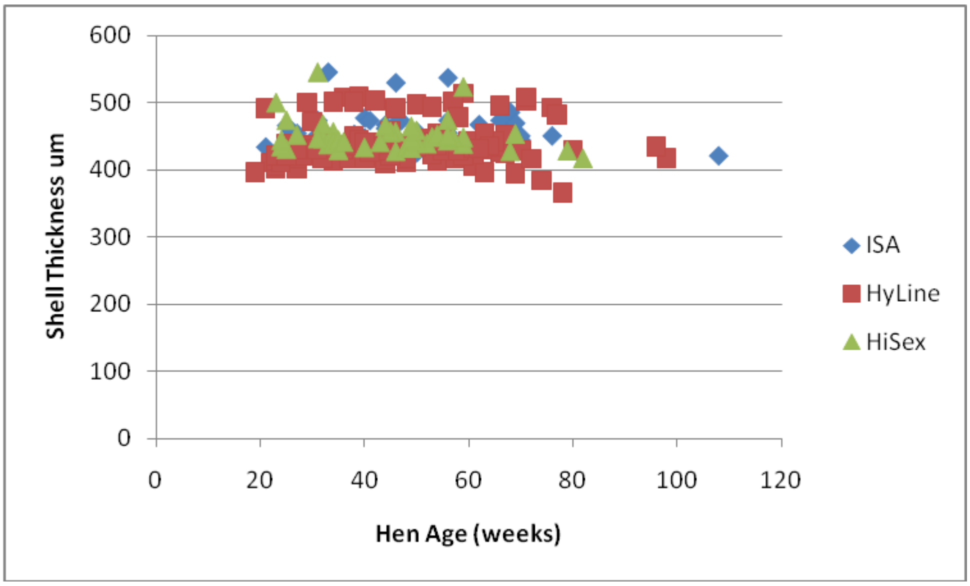
Shell breaking strength decreased with hen age and, although there was a considerable degree of overlap, some flocks were below the average.

Figure 3.3.2.5 Shell Weight (grams) versus hen age by strain



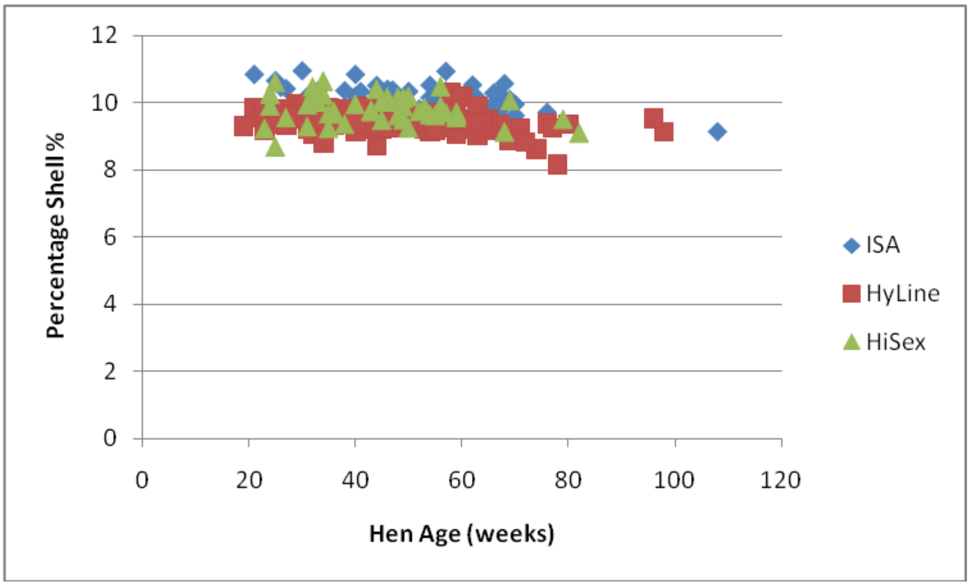
Shell weight increase between 20 and 30 weeks of age and, for some flocks, tended to decrease later in lay. Shell weight was generally highest for ISA and lowest for HyLine.

Figure 3.3.2.6 Shell Thickness (μm) versus hen age by strain



Shell thickness remained relatively stable across hen age, with some tendency to decline later in lay.

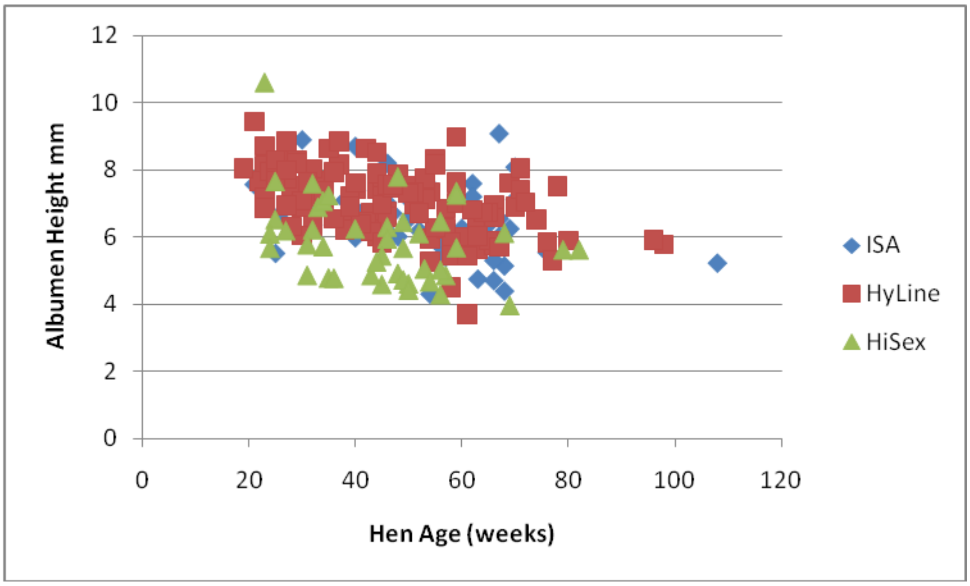
Figure 3.3.2.7 Percentage Shell (%) versus hen age by strain



Percentage shell decreased with increasing hen age and was generally similar for all strains.

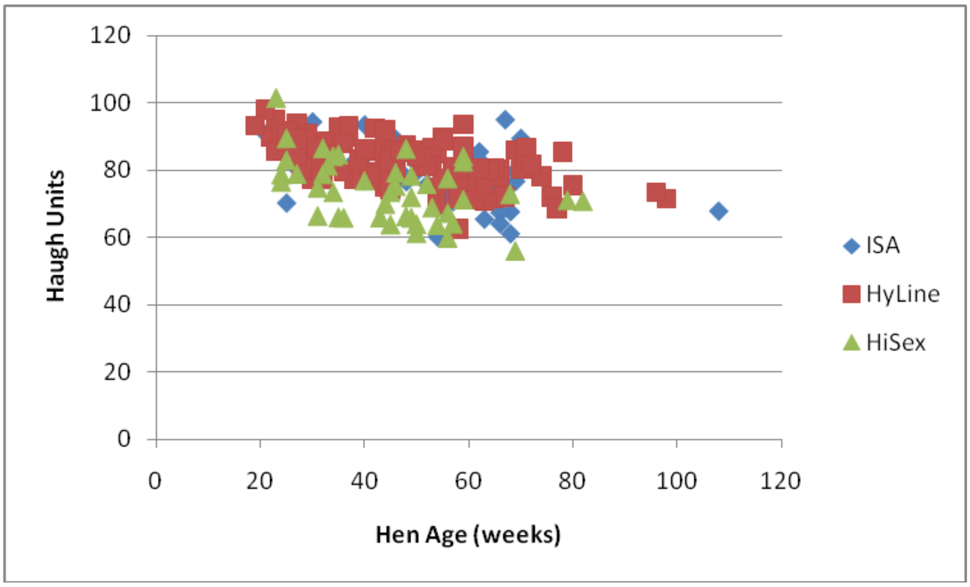
3.3.2.2 Egg Internal Quality

Figure 3.3.2.8 Albumen Height (mm) versus hen age by strain



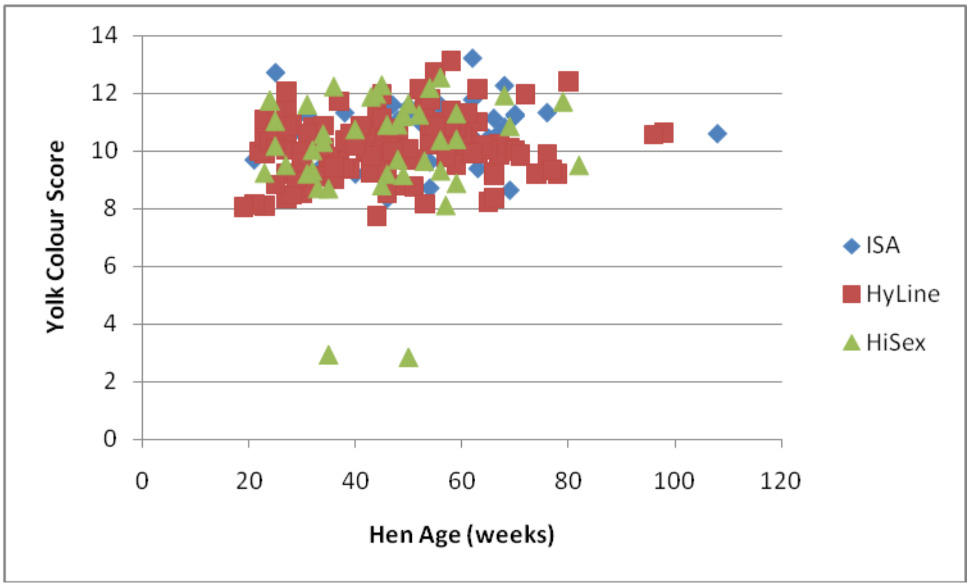
Albumen height measured in the laboratory showed considerable variation because of the different amounts of time that had elapsed between the collection of the eggs and their analysis in the laboratory.

Figure 3.3.2.9 Haugh Unit versus hen age by strain



Haugh unit measured in the laboratory varied in relation to the amount of time that had elapsed between egg collection and analysis.

Figure 3.3.2.10 Yolk Colour Score versus age by strain

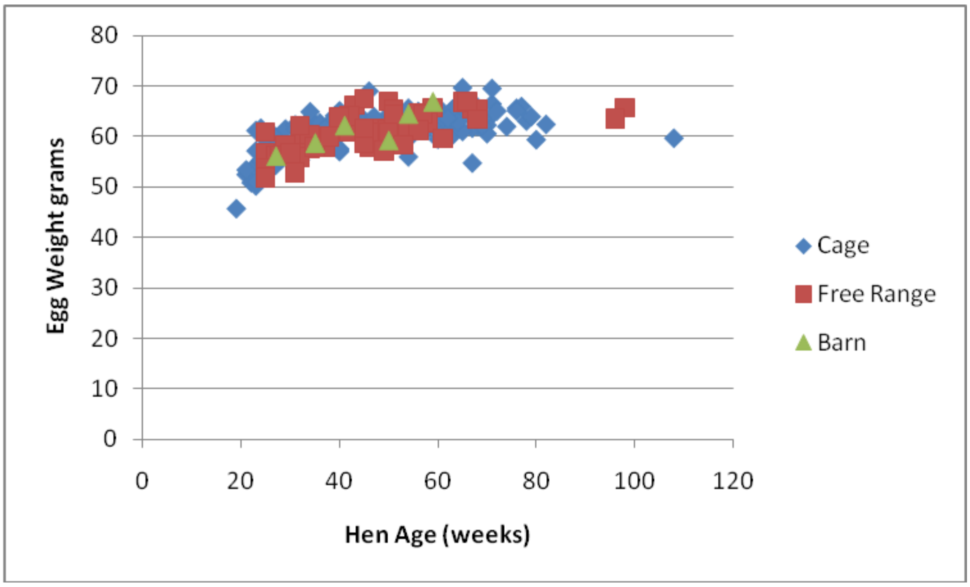


Yolk colour varied between 8 and 13 and was independent of hen age and strain. Two barn flocks from VIC were well below the average.

3.4 Egg Quality Data by Production System

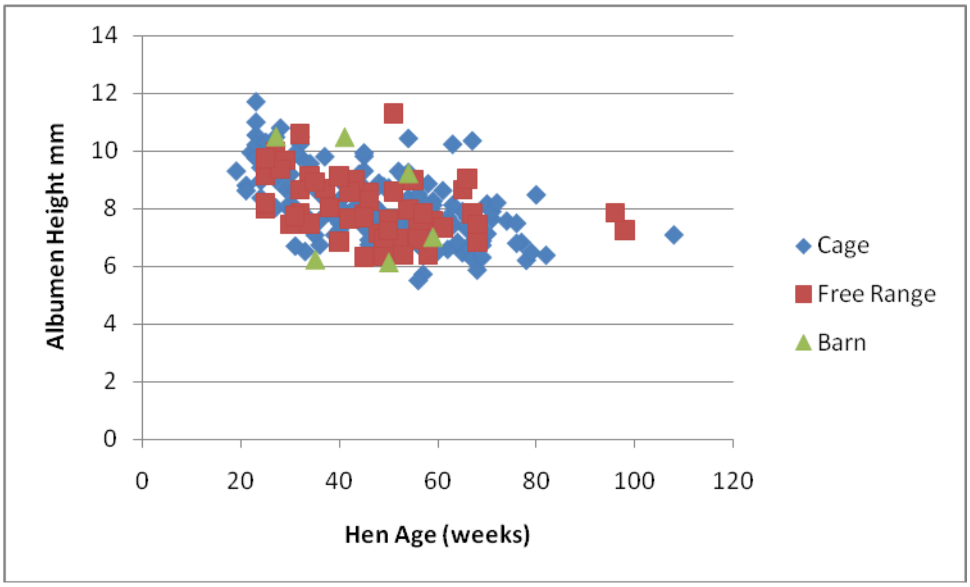
3.4.1 On Farm Egg Quality

Figure 3.4.1.1 Egg Weight (grams) versus hen age by production system



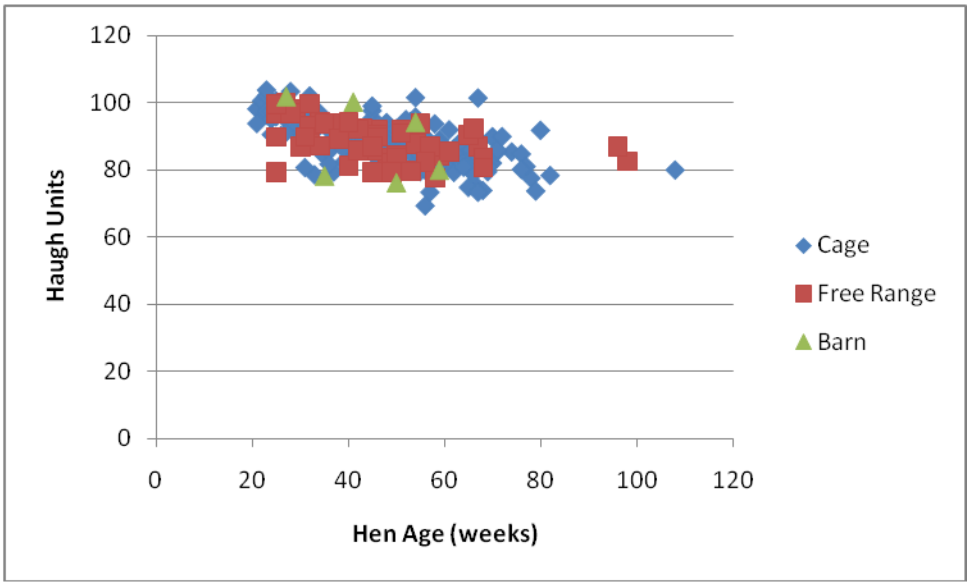
Egg weight increased with hen age and there were no differences among production systems

Figure 3.4.1.2 Albumen Height (mm) versus hen age by production system



Albumen height, measured on-farm, generally declined with hen age. There was considerable variation among flocks but no clear correlation with production system.

Figure 3.4.1.3 Haugh Unit versus hen age by production system

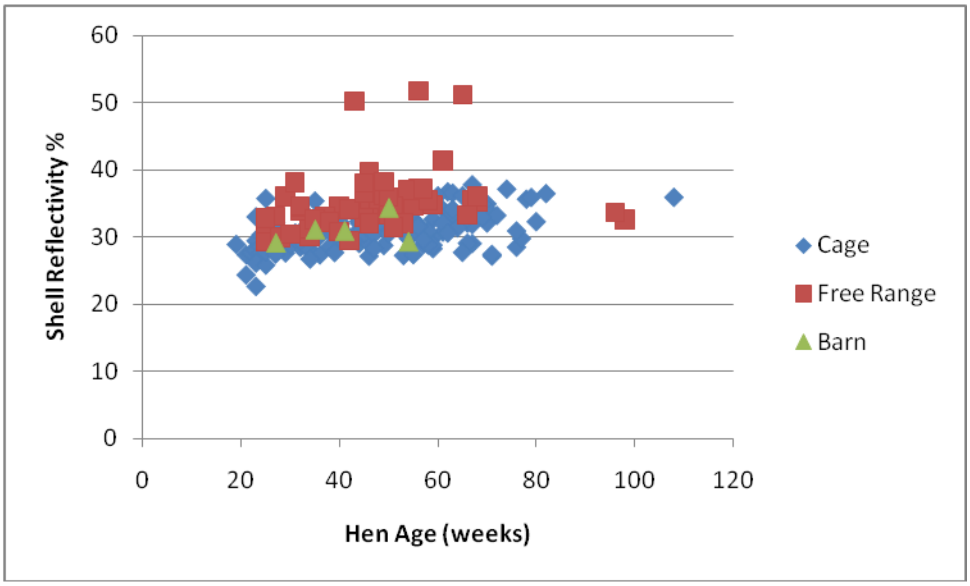


Haugh unit measured on-farm decreased with hen age. There was no difference among production systems.

3.4.2 Laboratory Analyses of Egg Quality

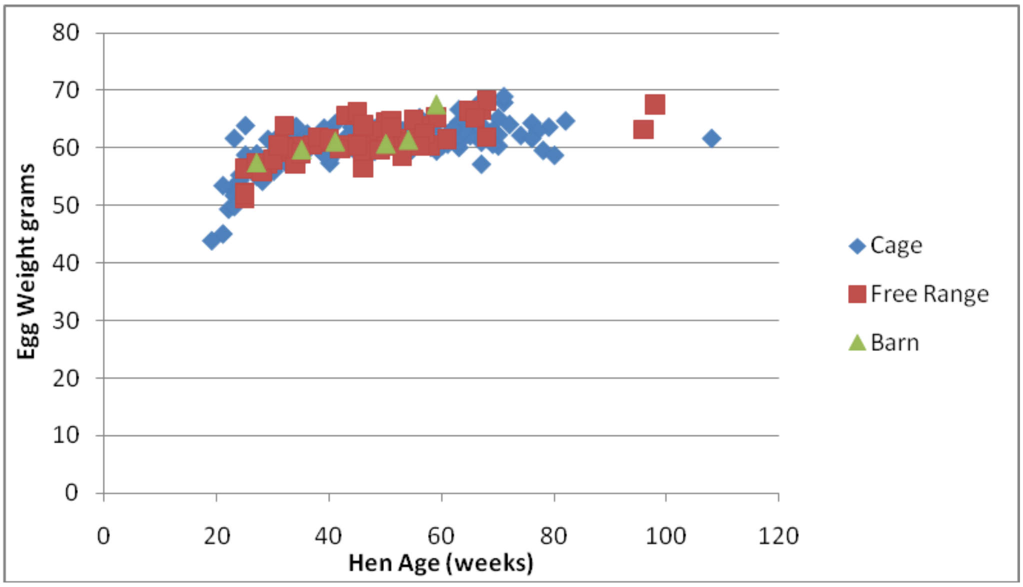
Egg Shell Quality

Figure 3.4.2.1 Shell Reflectivity (%) versus hen age by production system



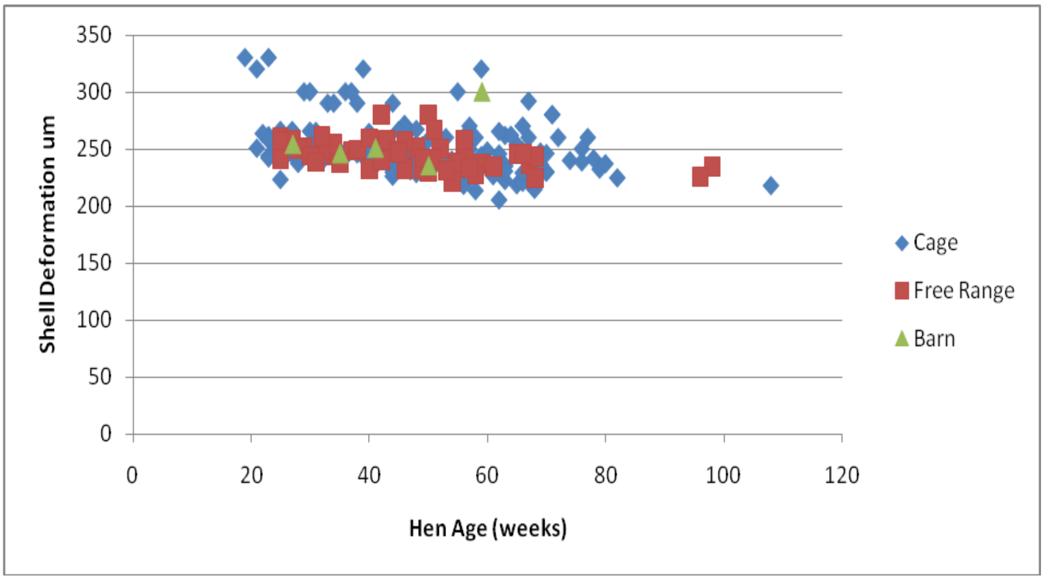
Shell reflectivity was generally higher for free range flocks with several flocks well above average.

Figure 3.4.2.2 Egg Weight (grams) versus hen age by production system



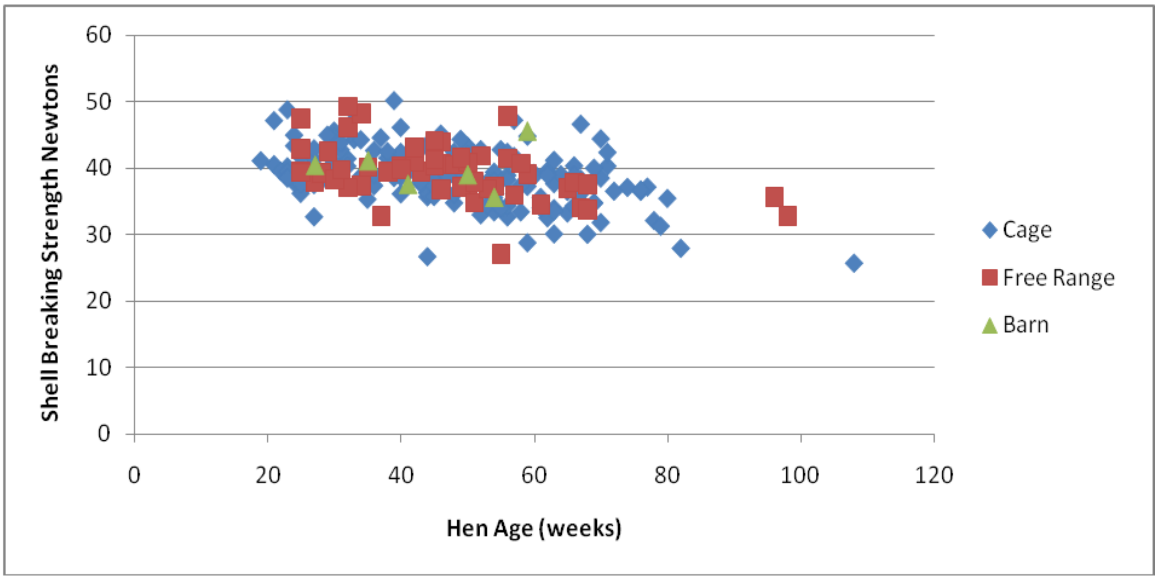
Egg weight measured in the laboratory showed a similar pattern to that measured on-farm.

Figure 3.4.2.3 Shell Deformation (μm) versus hen age by production system



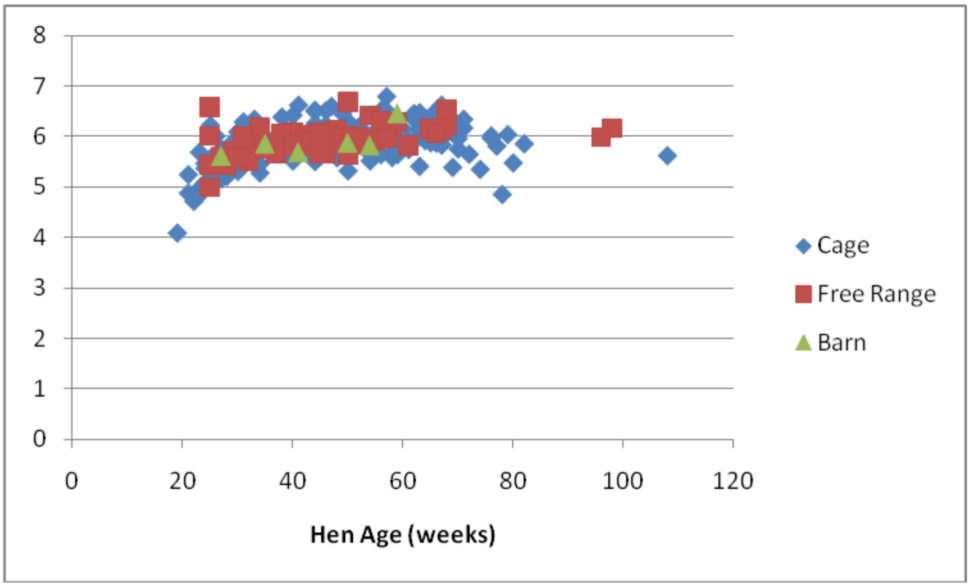
Shell deformation decreased with hen age. Values were higher for flocks whose eggs were analysed at QDPI&F which may reflect different laboratory technique. With the exception of these eggs, there were no differences among production systems.

Figure 3.4.2.4 Shell Breaking Strength (Newtons) versus hen age by production system



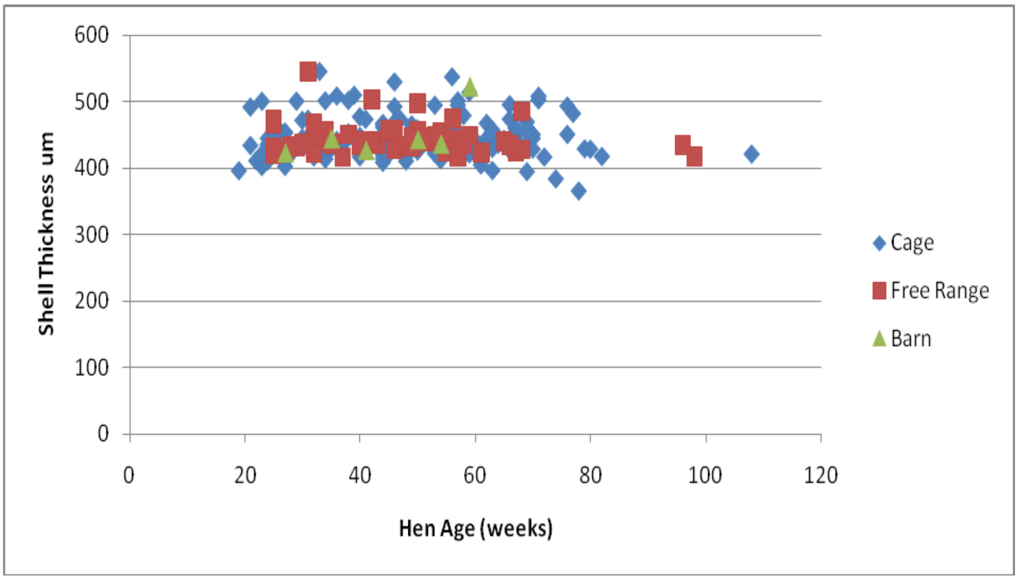
Shell breaking strength varied considerably within any given age category but was not different among production systems.

Figure 3.4.2.5 Shell Weight (grams) versus hen age by production system



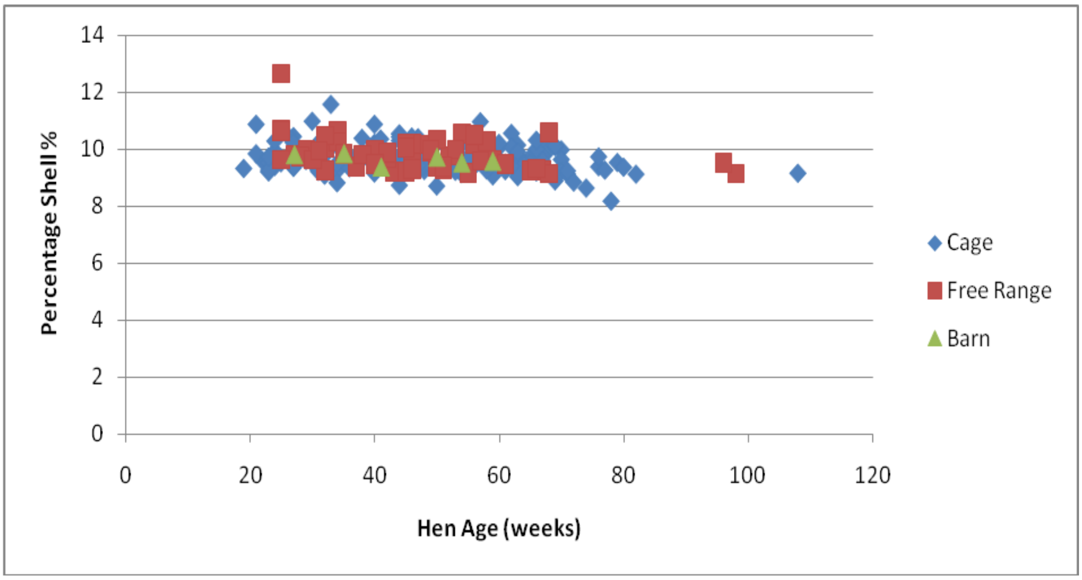
Shell weight was generally higher for ISA than for the other two strains.

Figure 3.4.2.6 Shell Thickness (μm) versus hen age by production system



Shell thickness remained relatively constant across a range of hen ages. However, it declined later in lay, especially in some of the cage flocks.

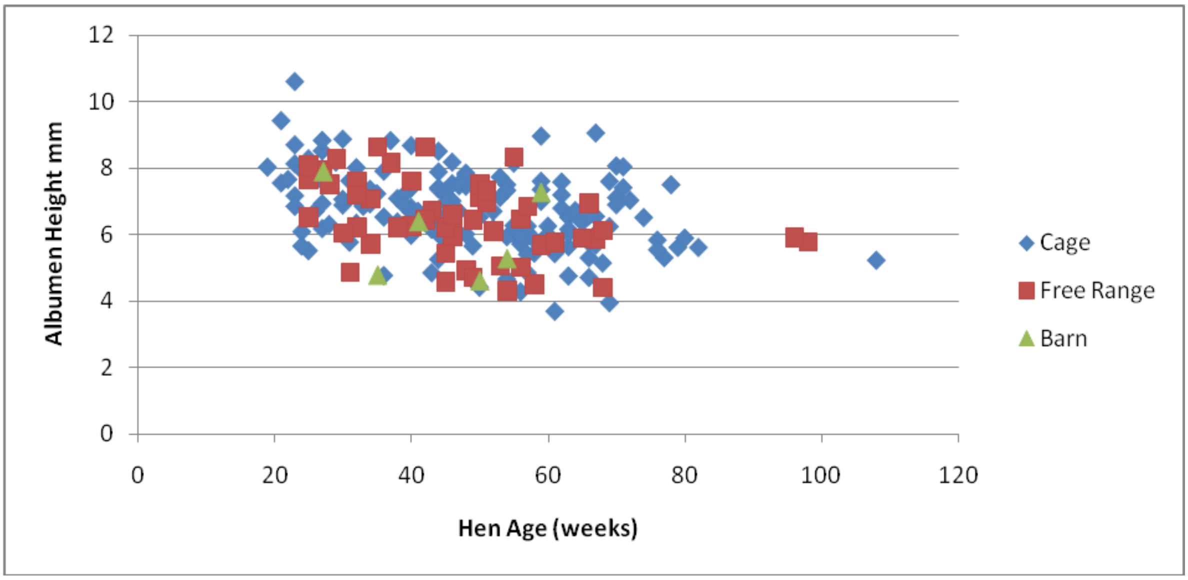
Figure 3.4.2.7 Percentage Shell (%) versus hen age by production system



Percentage shell remained relatively constant until approximately 70 weeks of age, after which it tended to decrease.

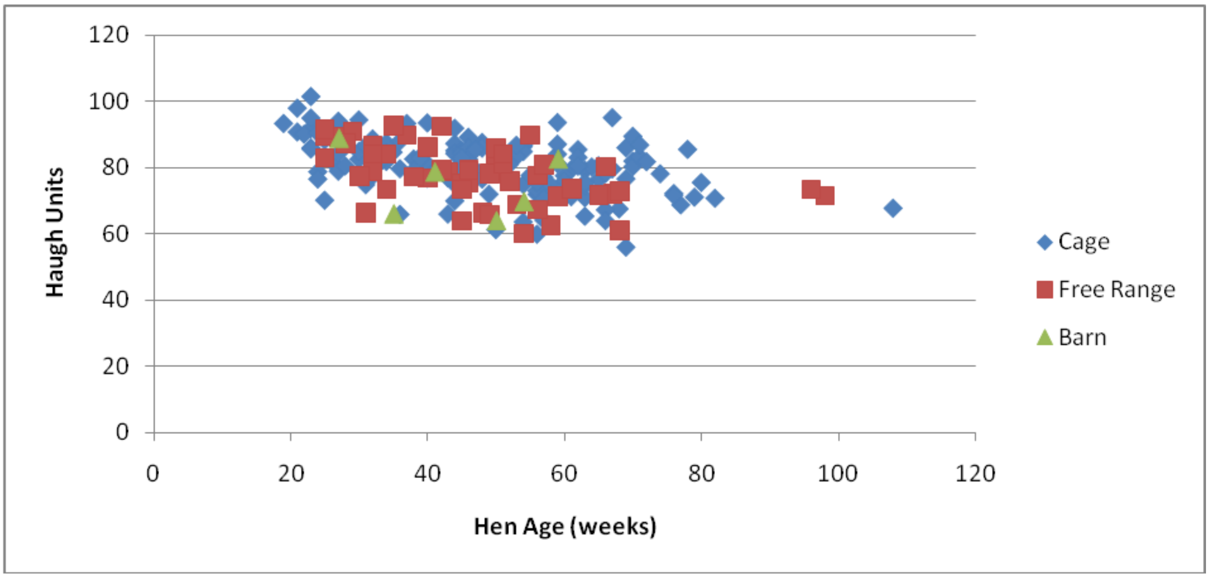
Egg Internal Quality

Figure 3.4.2.8 Albumen Height (mm) versus hen age by production system



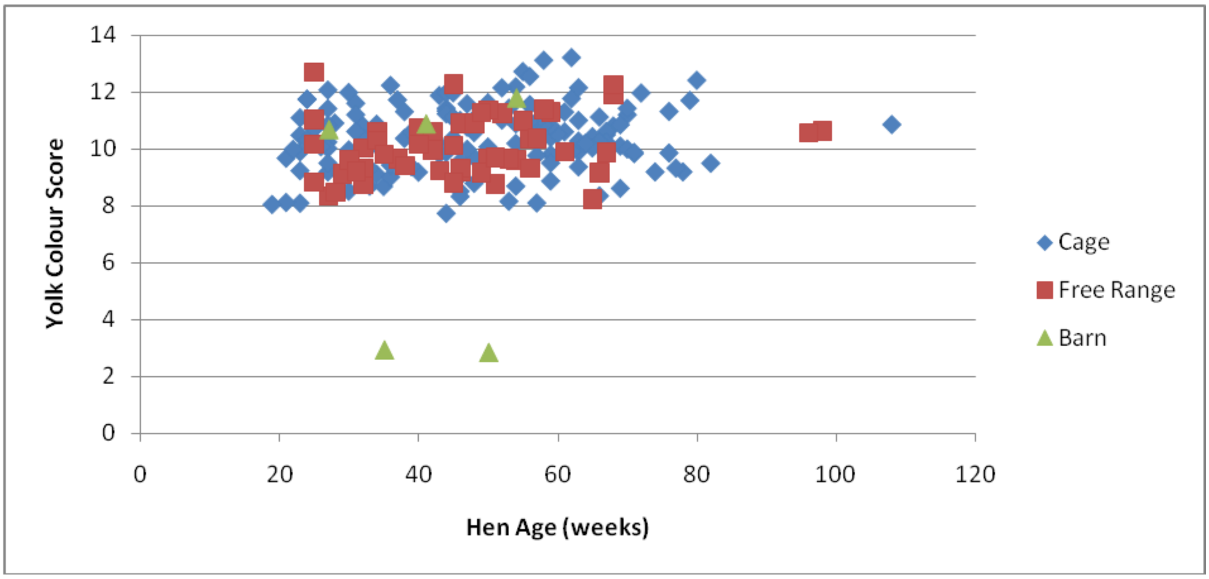
Albumen height measured in the laboratory varied greatly because of the variable time interval between collection of the eggs and measurement in the laboratory. However, albumen height decreased overall with increasing hen age.

Figure 3.4.2.9 Haugh Unit versus hen age by production system



Haugh unit measured in the laboratory varied greatly because of the variable time interval between collection of the eggs and measurement in the laboratory. However, Haugh unit decreased overall with increasing hen age.

Figure 3.4.2.10 Yolk Colour Score versus hen age by production system

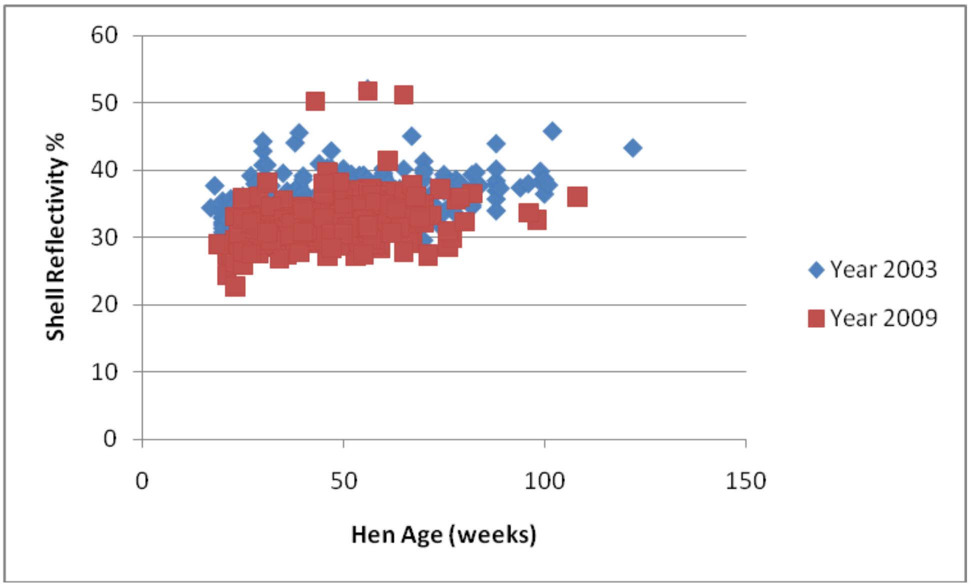


Yolk score was independent of hen age and production system. There were two barn flocks which had very low yolk colour score.

3.5 Comparison of 2003 and 2009 Egg Quality Study Results

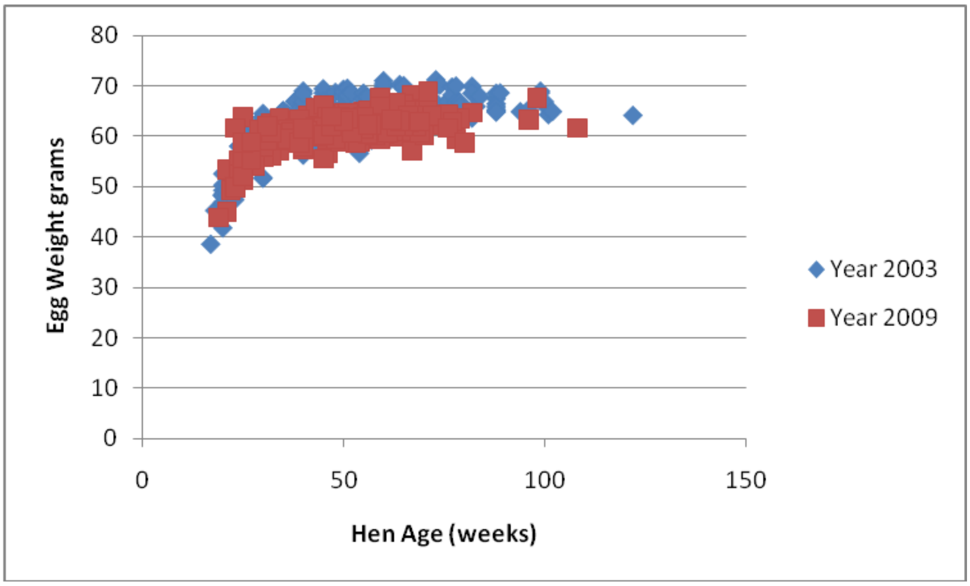
3.5.1 Egg Shell Quality

Figure 3.5.1.1 Shell Reflectivity (%)



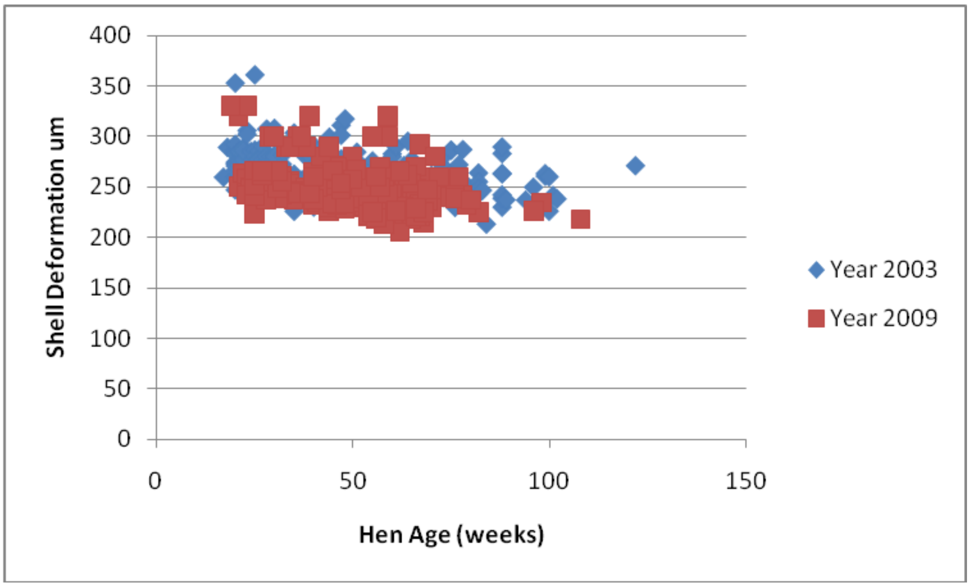
Egg shell colour measured in the 2009 study was generally darker (lower reflectivity) than for the 2003 study, with the exception of the three free range flocks, mentioned earlier.

Figure 3.5.1.2 Egg Weight (grams) by year of study



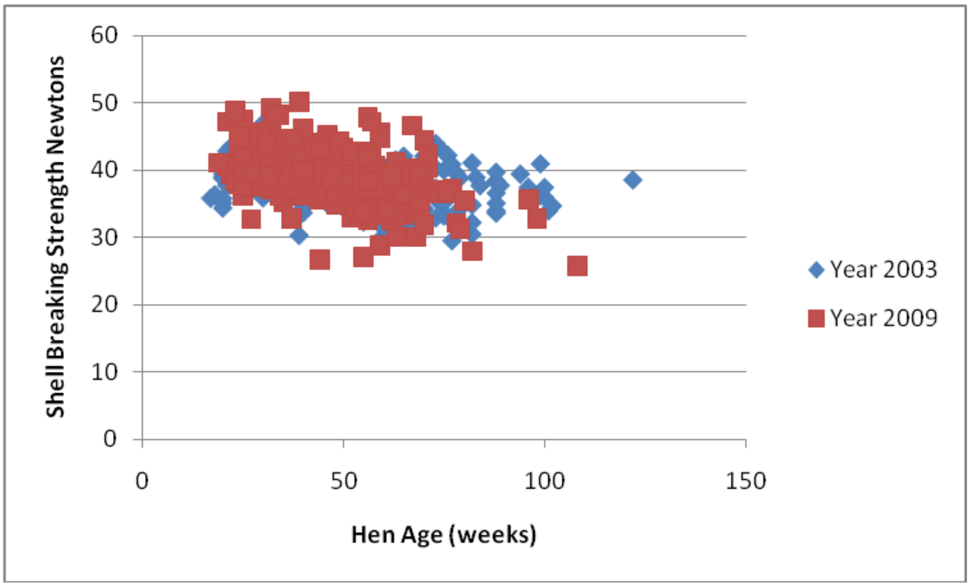
Egg weight in the 2009 study is generally lower than for the 2003 study.

Figure 3.5.1.3 Shell Deformation (um) by year of study



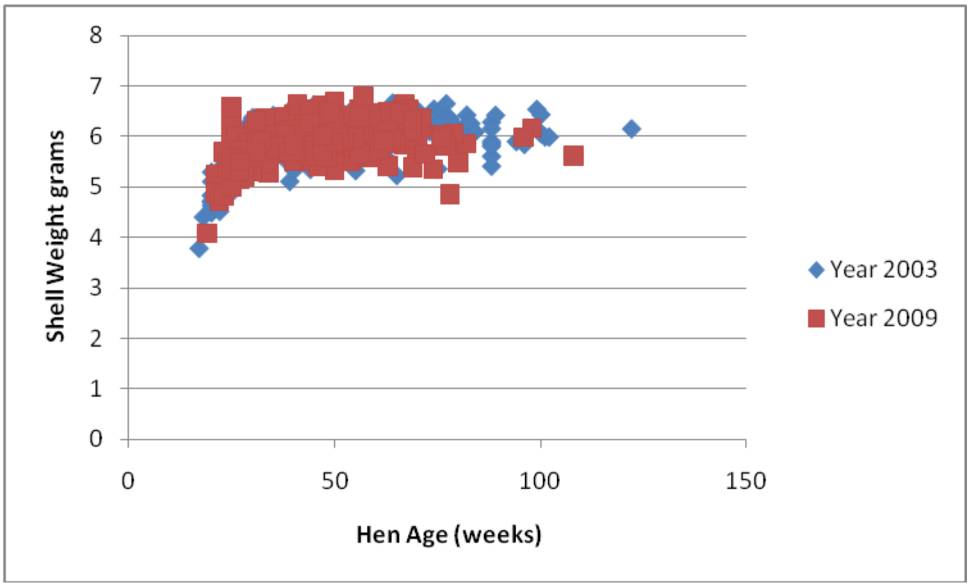
Shell deformation measured in the 2009 study tended to be lower than for the 2003 study.

Figure 3.5.1.4 Shell Breaking Strength (Newtons) by year of study



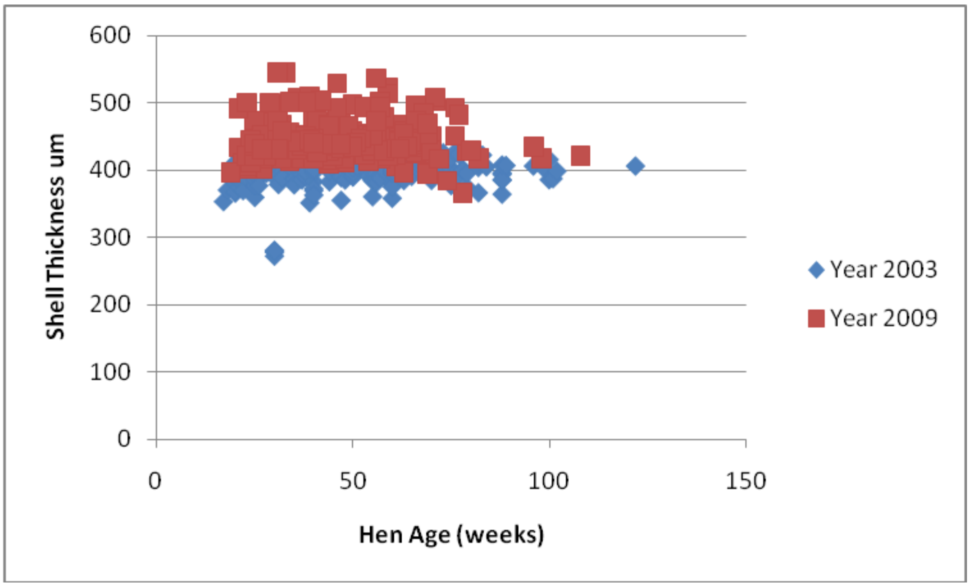
Shell breaking strength was very similar for the two studies.

Figure 3.5.1.5 Shell Weight (grams) by year of study



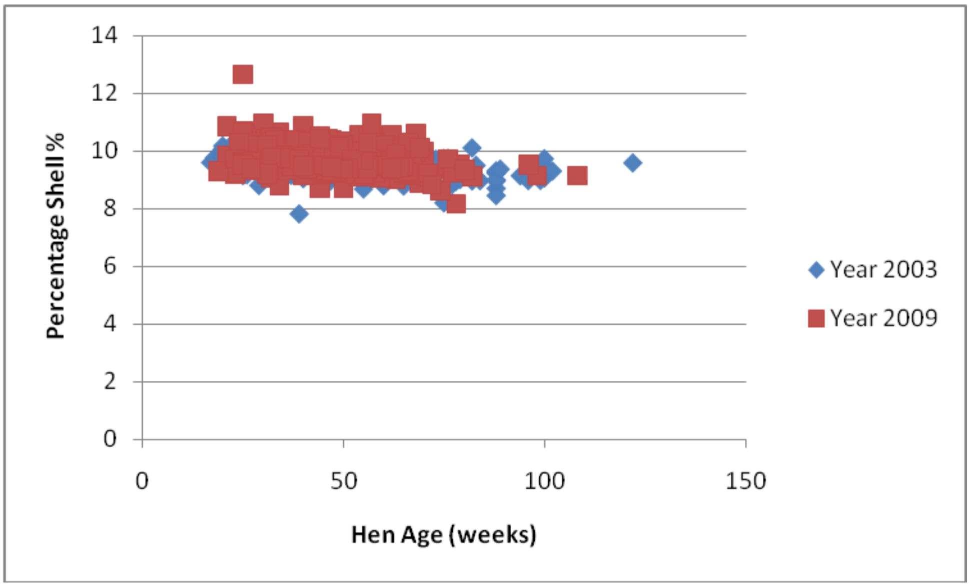
Shell weight was very similar for the two studies.

Figure 3.5.1.6 Shell Thickness (µm) by year of study



Shell thickness tended to be higher for the 2009 study.

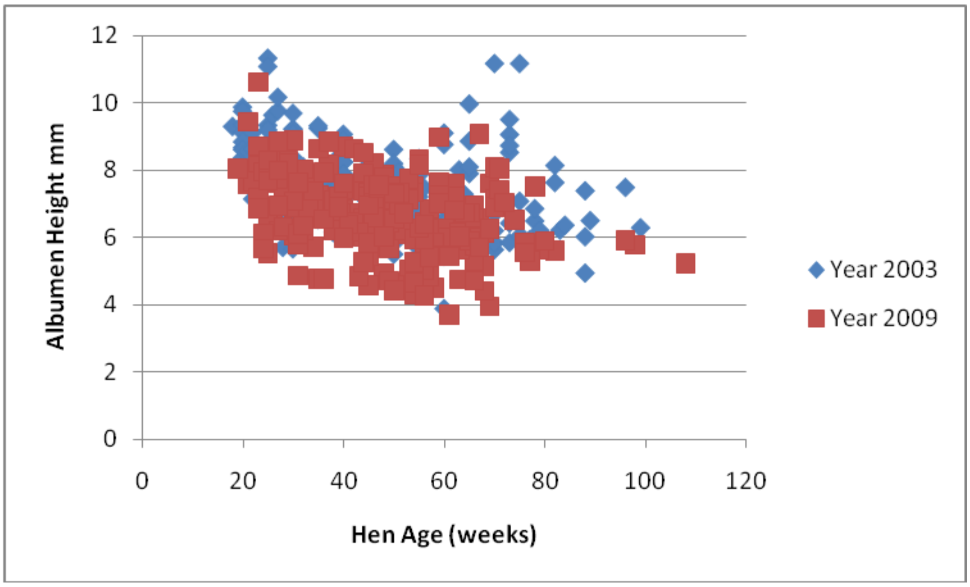
Figure 3.5.1.7 Percentage Shell (%) by year of study



Percentage shell was very similar for the 2003 and 2009 studies.

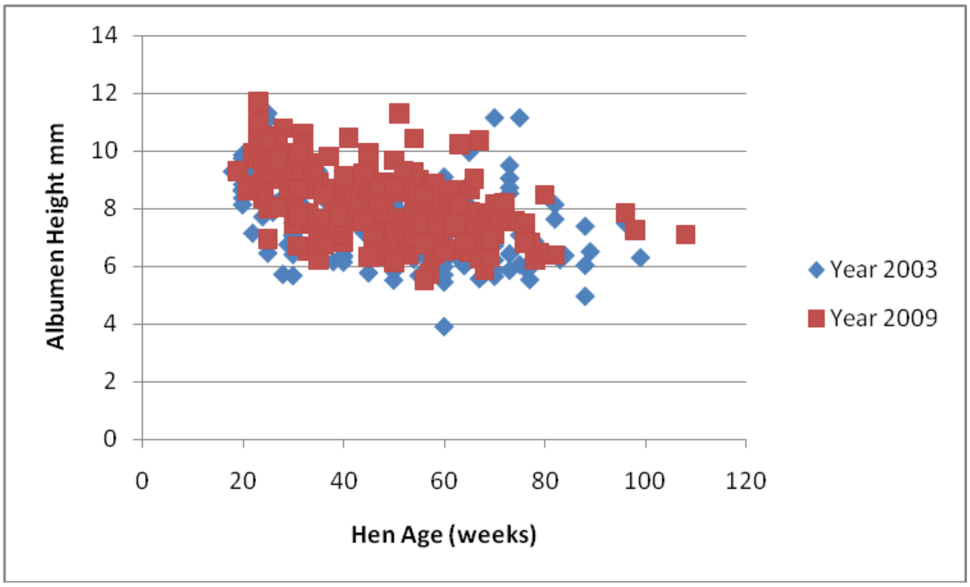
Egg Internal Quality

Figure 3.5.1.8 Albumen Height (mm) measured in the laboratory in 2003 and 2009



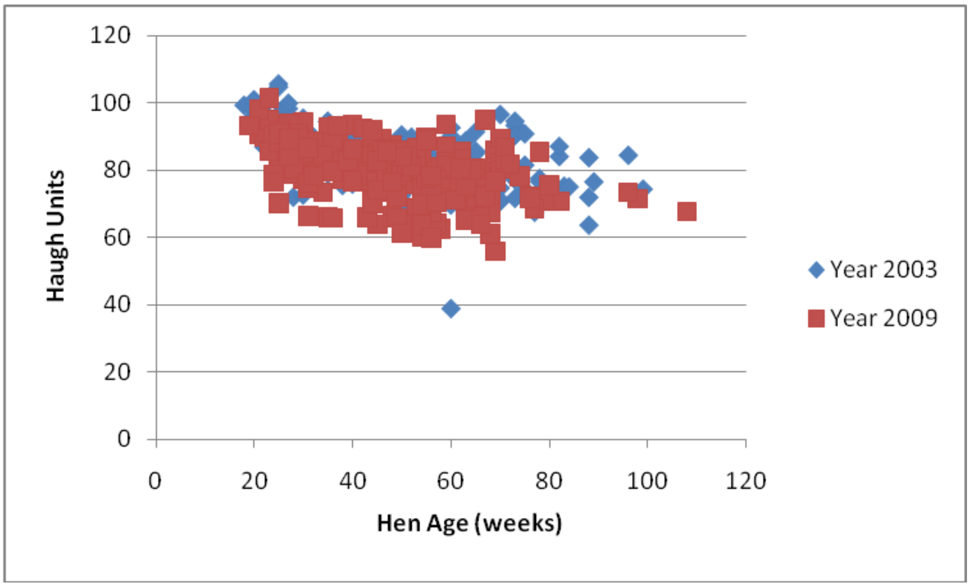
Albumen height measured in the laboratory in 2003 was generally higher than that measured in the laboratory in 2009

Figure 3.5.1.9 Albumen Height (mm) measured in the laboratory in 2003 and on-farm in 2009



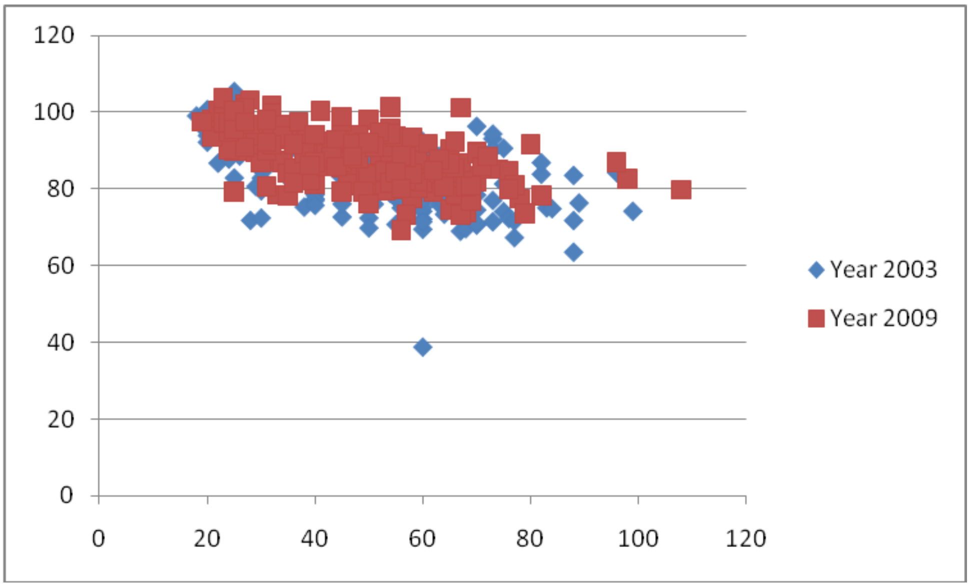
Albumen height measured in the laboratory in 2003 and on-farm in 2009 was very similar for the two studies.

Figure 3.5.1.10 Haugh Unit measured in the laboratory in 2003 and 2009



Haugh Unit measured in the laboratory in 2003 tended to be higher than that measured in the laboratory in 2009

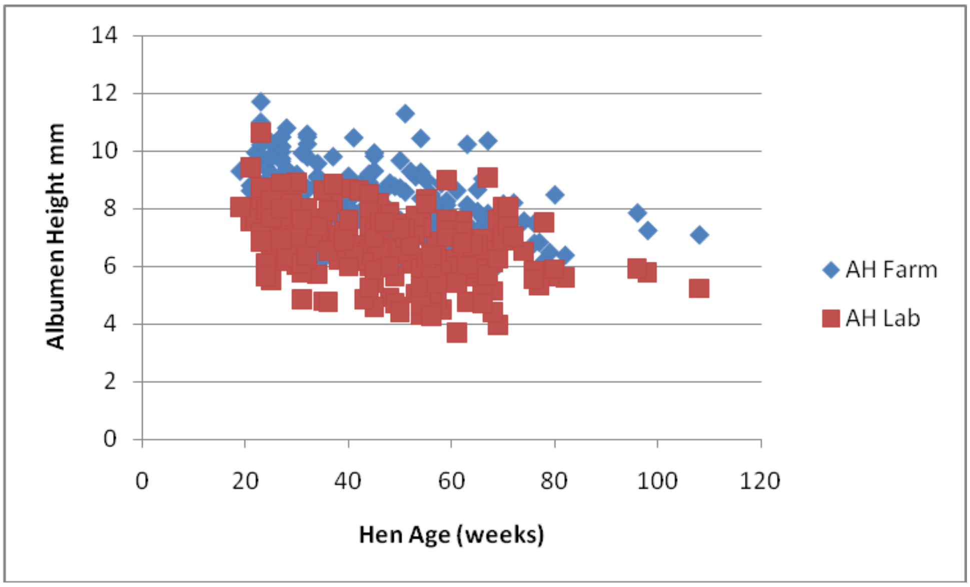
Figure 3.5.1.11 Haugh Unit measured in the laboratory in 2003 and on farm in 2009



Haugh Unit measured on-farm in 2009 tended to be higher than that measured in the laboratory in 2003.

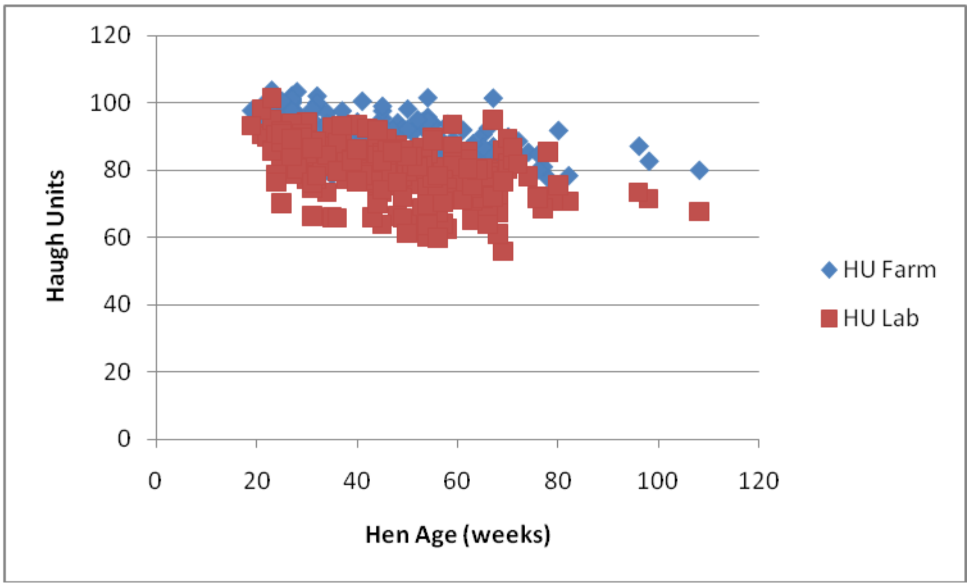
3.6 Haugh Unit: Comparison of measurement at cage front and measured later in the lab

Figure 3.6.1.1 Albumen Height (mm) versus hen age, measured on-farm and in the lab



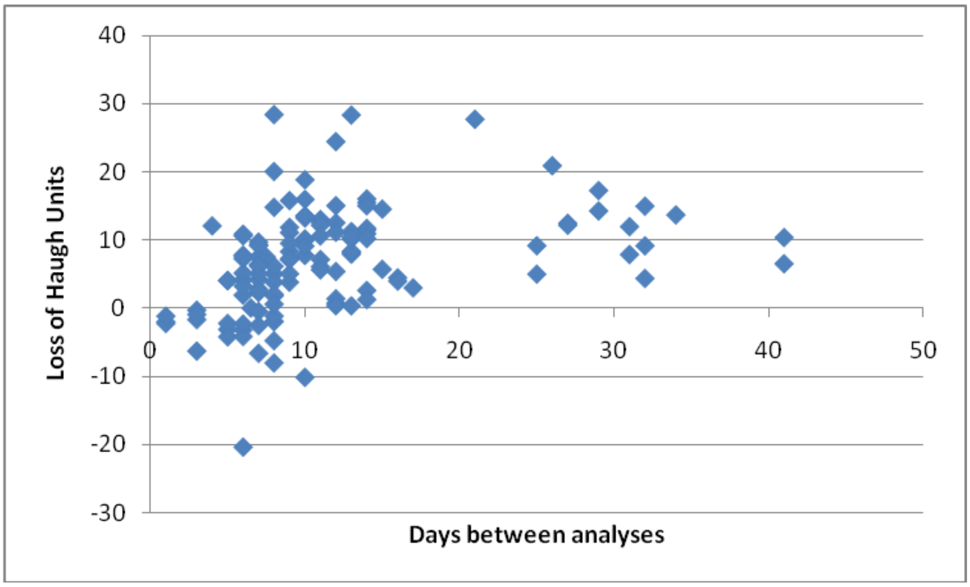
Albumen height was higher when measured on-farm than when measured at varying time intervals later in the laboratory.

Figure 3.6.1.2 Haugh Unit versus hen age, measured on-farm and in the lab



Haugh Unit was higher when measured on-farm than when measured later in the laboratory.

Figure 3.6.1.3 Loss in Haugh Units with time (days) to analysis

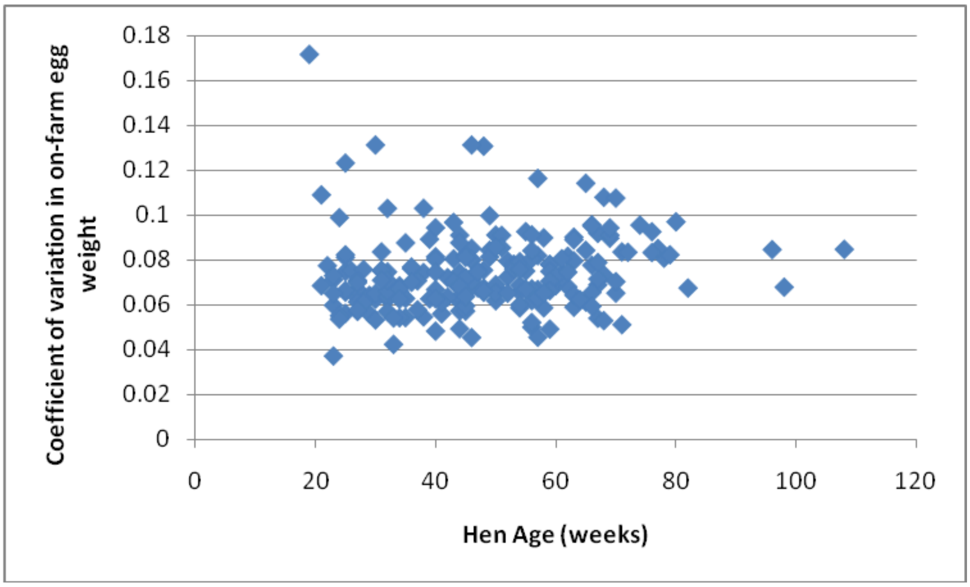


When the loss in Haugh Units with time between on-farm analysis and analysis later in the laboratory are plotted on a graph, it can be seen that, for most flocks, there is a loss of Haugh Unit but, for other flocks, Haugh Unit was actually higher when measured in the laboratory. In general, the loss of Haugh Units was between 1 and 10 up to 15 days between analyses and between 10 and 20 for longer time delays between analyses.

3.7 Variation within flocks

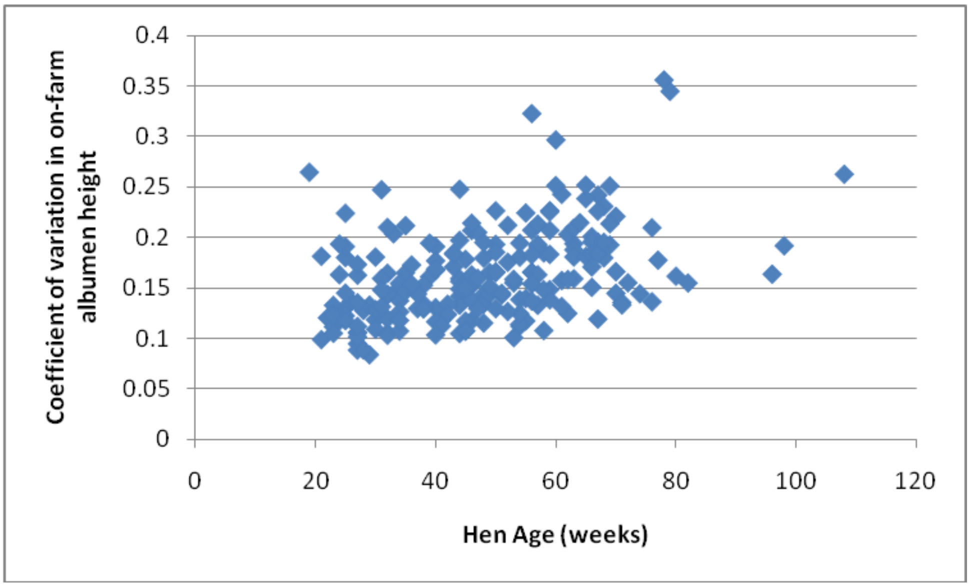
3.7.1 Egg Internal Quality

Figure 3.7.1.1 Variation in on-farm egg weight in relation to hen age



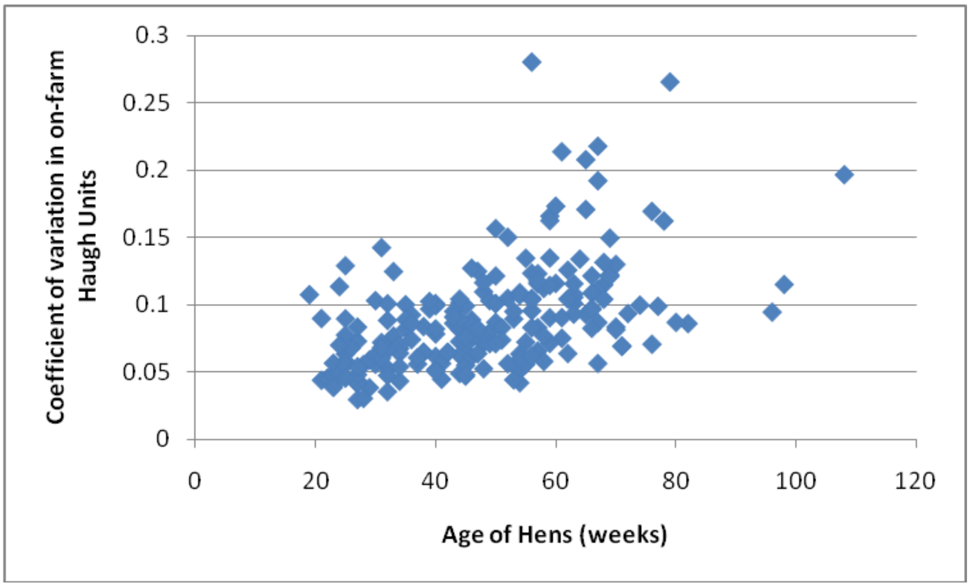
The coefficient of variation (CV - standard deviation divided by mean) is a reliable indicator of the variability that exists within a population. For most of the flocks, the coefficient of variation in on-farm egg weight was below 0.1 (10%), indicating that most flocks were relatively uniform for egg weight.

Figure 3.7.1.2 Variation in on-farm albumen height in relation to hen age



In comparison with egg weight, on-farm albumen height was more variable. Most flocks had a CV below 20% but some were as high as 30-35%.

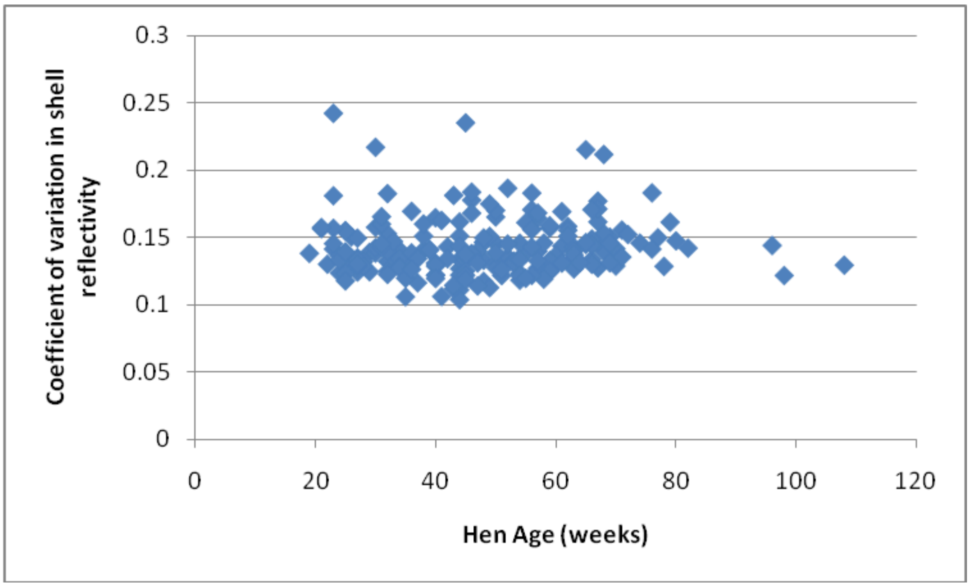
Figure 3.7.1.3 Variation in on-farm Haugh Units in relation to hen age



For most flocks, the coefficient of variation (CV) was below 10%. In general, the amount of variability increased with hen age. However, some flocks of relatively young birds had CV greater than 10%.

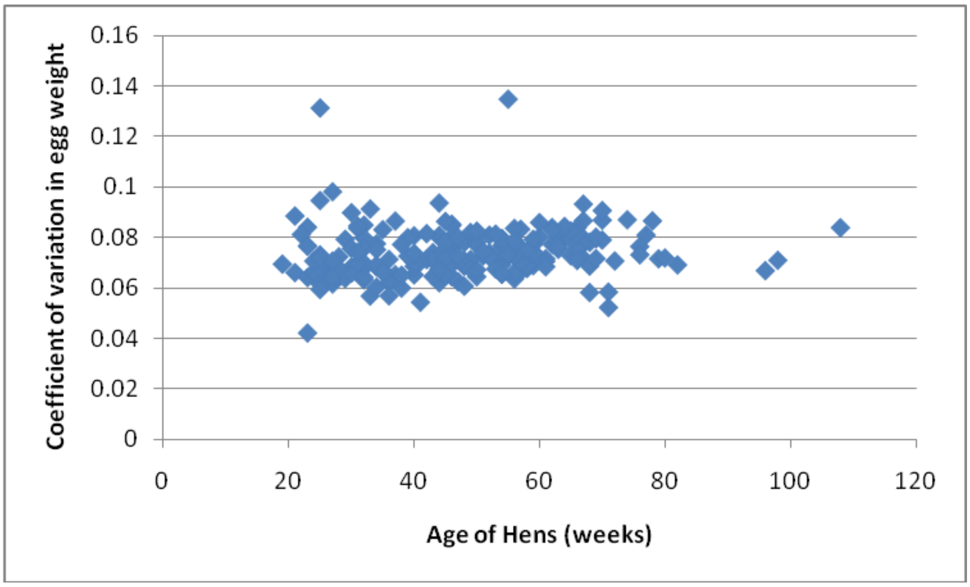
3.7.2 Egg Shell Quality

Figure 3.7.2.1 Variation in shell reflectivity in relation to hen age



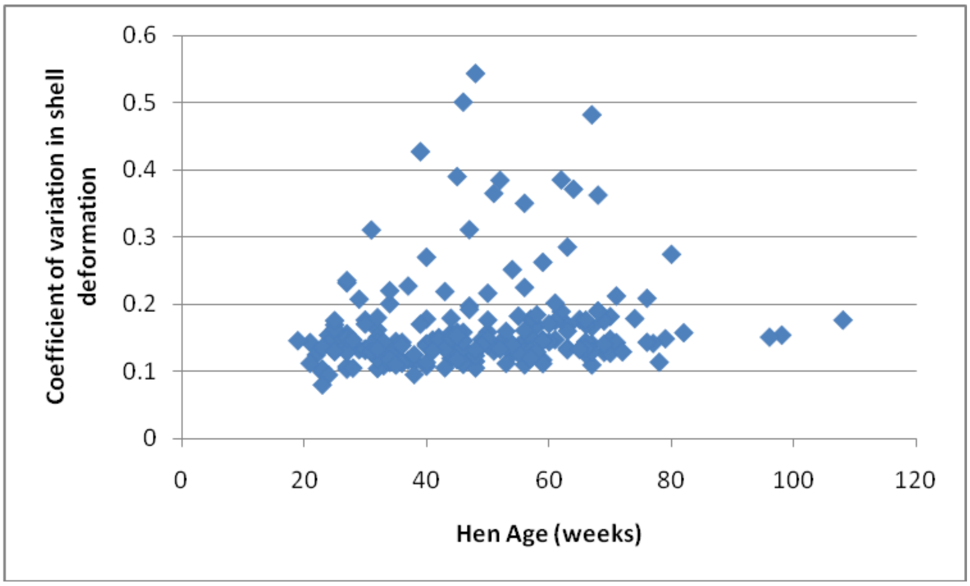
The shell colour within flocks was moderately variable, with CV between 10 and 20%. There was no clear correlation with hen age.

Figure 3.7.2.2 Variation in egg weight in relation to hen age



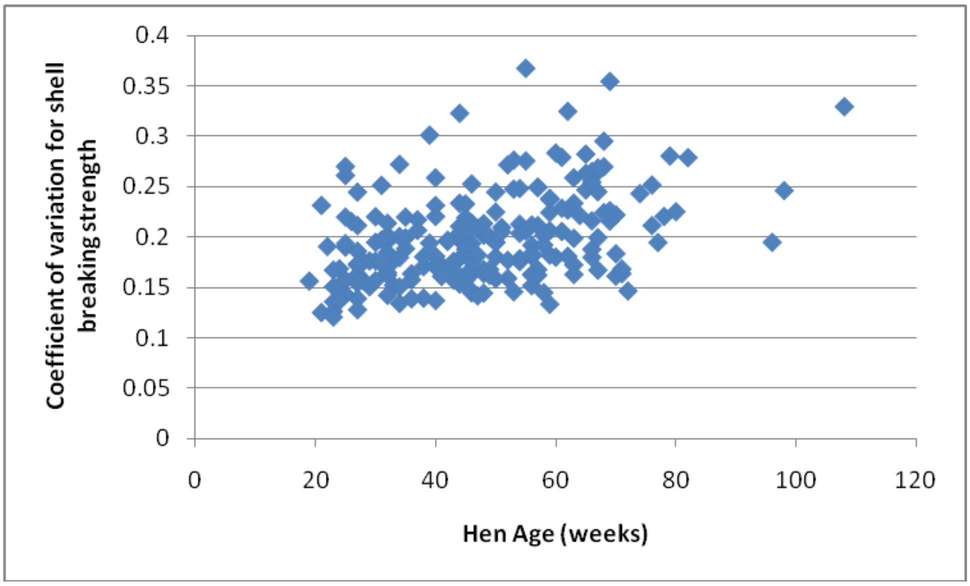
The egg weight measured in the laboratory was less variable within flocks than that measured on-farm, due, at least in part, to the larger sample size. Only two flocks had a CV above 10%.

Figure 3.7.2.3 Variation in shell deformation in relation to hen age



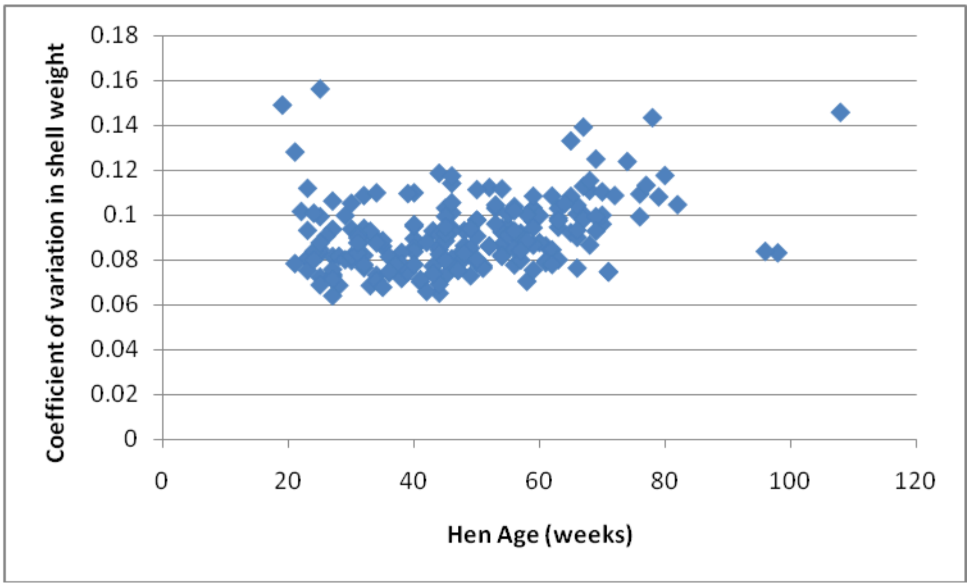
CV of shell deformation was, in general, below 20%.

Figure 3.7.2.4 Variation in shell breaking strength in relation to hen age



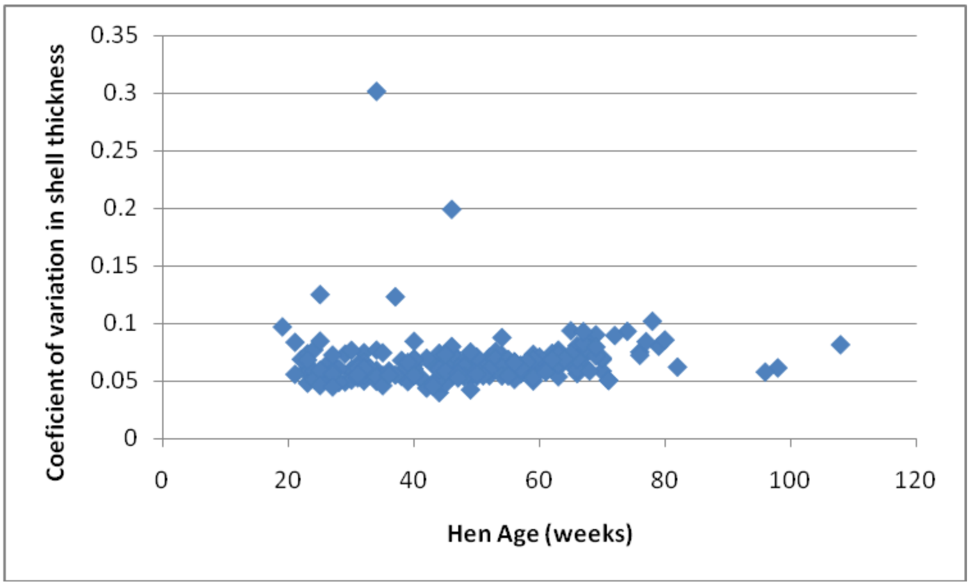
The variability in egg shell breaking strength was relatively high, with most flocks between 12 and 25% but some flocks as high as 35% or more.

Figure 3.7.2.5 Variation in shell weight in relation to hen age



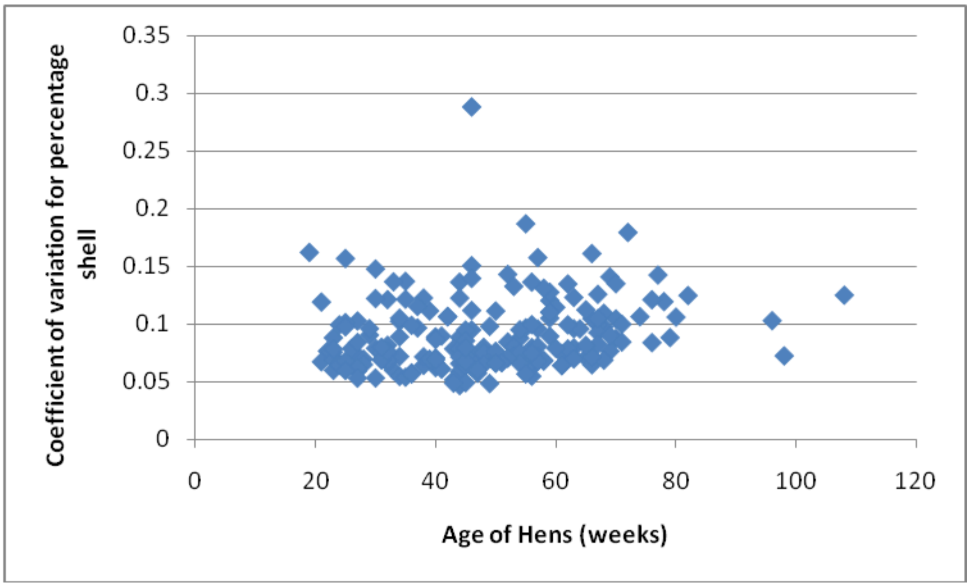
With only a small number of exceptions, the CV for shell weight was between 6 and 12 %.

Figure 3.7.2.6 Variation in shell thickness in relation to hen age



Shell thickness was relatively uniform within a flock with CV of between 5 and 10%. Only a few flocks, which had very thin shelled eggs, had higher CV.

Figure 3.7.2.7 Variation in percentage shell in relation to hen age

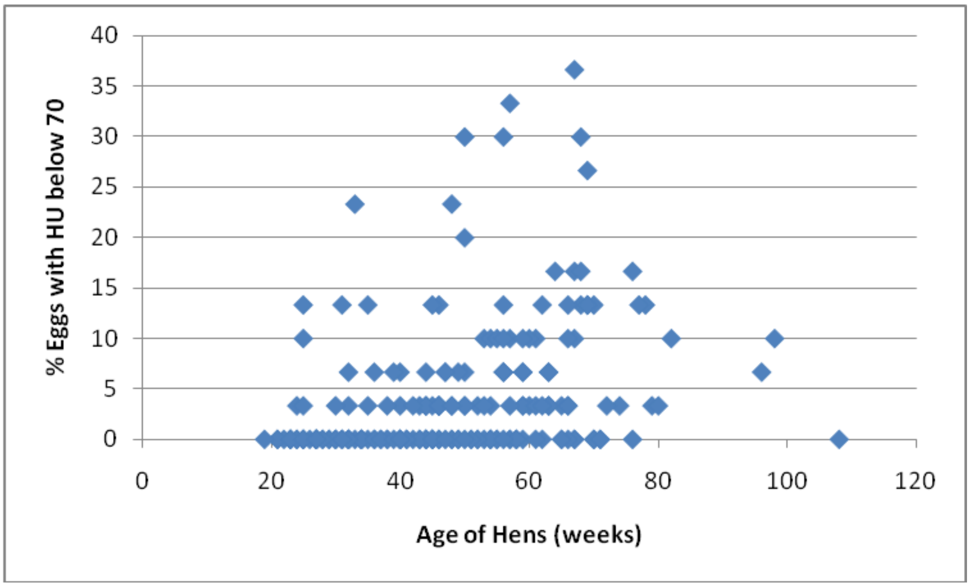


The CV for percentage shell was between 5 and 15% for most flocks.

3.8 Comparison of results obtained against arbitrary standards

3.8.1 Egg internal quality

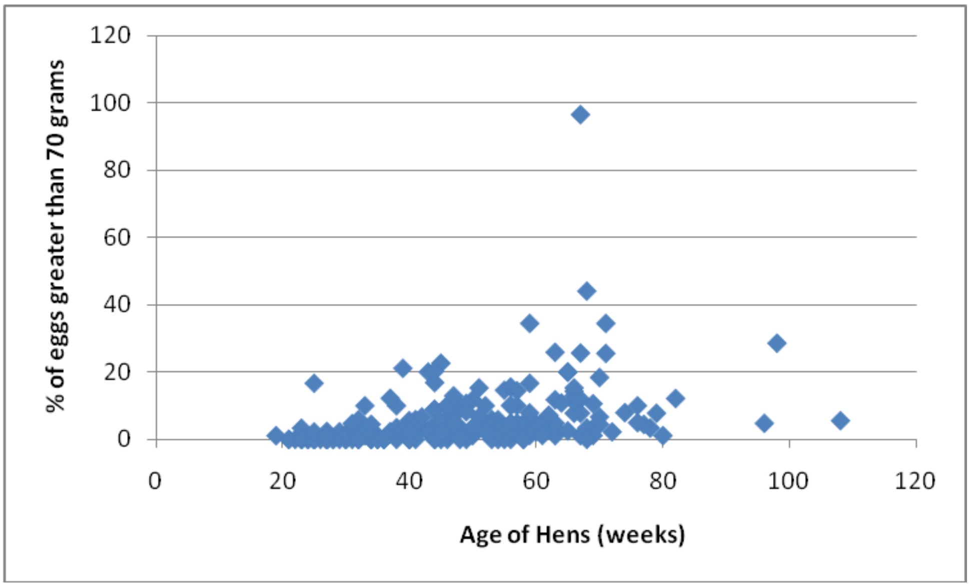
Figure 3.8.1.1 Percentage of eggs measured on-farm with Haugh Units less than 70



As can be seen from the graph, some flocks at all ages were producing at least some eggs with Haugh Units below 70. At the same time, some flocks as old as 78 weeks of age had no eggs with Haugh Units below 70.

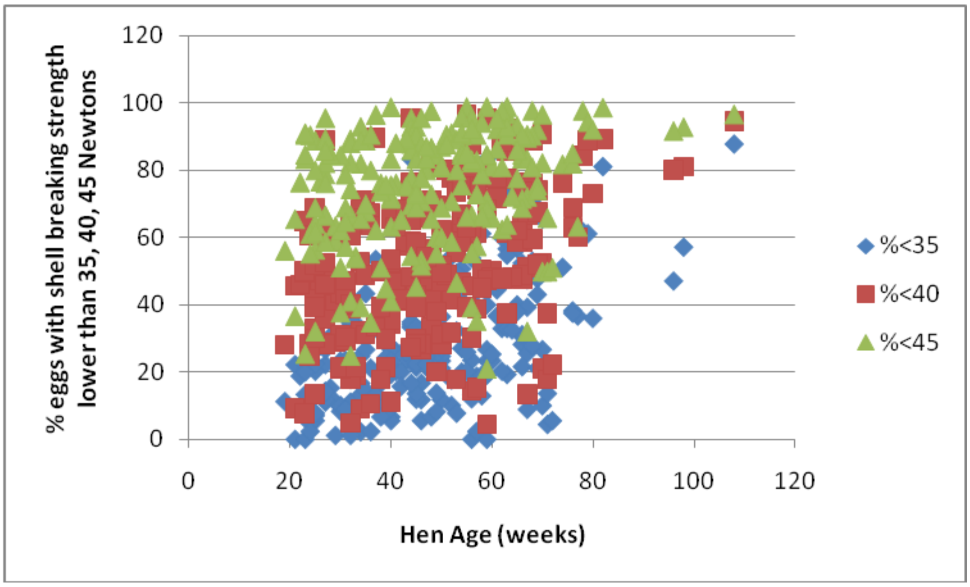
3.8.2 Egg shell quality

Figure 3.8.2.1 Percentage of eggs with egg weight greater than 70 g



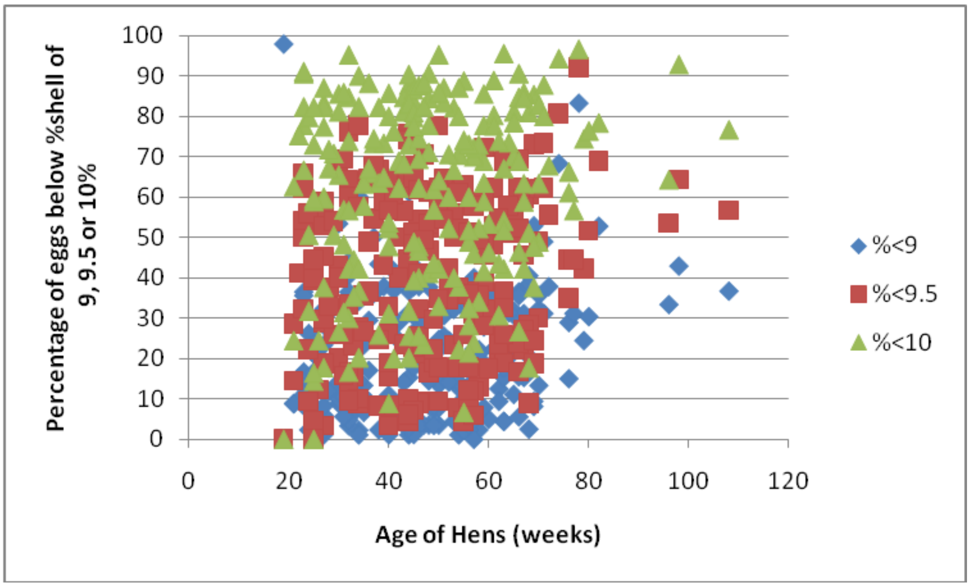
Most flocks studied had no eggs above 70 grams weight. One flock had all its eggs above 70 grams.

Figure 3.8.2.2 Percentage of eggs with shell breaking strength less than 35, 40 and 45 Newtons



This figure shows the percentage of eggs below 35, 40 and 45 Newtons for egg shell breaking strength. It can be seen that there is considerable variation among flocks, at any particular age of hen, in the distribution of egg shell breaking strength. Most flocks had at least 20% of eggs with breaking strength below 45 Newtons, with some flocks having almost all eggs below 45 Newtons.

Figure 3.8.2.3 Percentage of eggs measured with percentage shell less than 9, 9.5 and 10%



There was a considerable range of CV for percentage shell in all categories of <9, <9.5 and <10%.

4. Discussion

4.1 Flock Characteristics

Flocks were sampled over a wide range of ages from early lay to very late in lay. Most of the flocks were from cage production systems (74%) followed by free range (22%) and then barn (4%). States were sampled in approximate proportion to the extent of the Australian egg industry production in each state. The cage flocks had the highest average number of birds (136, 818) followed by barn (97, 340) and then free range (54, 534). The largest number of flocks was HyLine birds (114 flocks), followed by Isa (52) and HiSex (44). Most flocks were single age and multiage flocks were reported only for 29% of cage flocks. Reticulated town water was the water source for most of the flocks (93) followed by bore water (78) and dam (29). The methods used to treat water coming from non-town sources was predominantly a combination of filtration and chlorination with some farms using reverse osmosis or iodine treatment. For cage production, most single age sheds had controlled ventilation and most multi-age cage flocks came from older style sheds with natural ventilation. Free range and barn flocks had shedding that was mainly naturally ventilated although some had some degree of ventilation control. Years of staff experience varied from less than one year to 60 years although the averages were similar for cage (22 years) and barn (23 years) which were higher than for the free range average (16 years). Most farms collected eggs at least daily although 17% of eggs from both cage and barn systems were collected only 6 days per week. The average temperature of egg storage rooms was 14°C for all production systems but varied from 9-17°C. Three quarters of cage flocks and approximately half of all free range and barn flocks were vaccinated for infectious bronchitis (IB) virus only during rearing. For flocks that were revaccinated regularly during lay, the frequency of revaccination generally ranged from every 6 to 10 weeks. Relatively few cage and free range flocks were reported as having shown signs of IB infection but this proportion was higher for barn flocks. The majority of flocks were audited regularly, most under ECA. Most farms used cardboard fillers. Age at first egg was similar for all production systems (17.5 weeks) with peak production occurring at 27-30 weeks of age and 90% at 44, 51 and 55 weeks of age for free range, cage and barn, respectively.

4.2 Effects of Flock Age

The effects of flock age were very similar to those which have been reported earlier. Egg weight increased and then stabilised at between 60 and 70 grams. Shell reflectivity increased with hen age initially but then remained relatively stable. Shell deformation generally decreased with hen age. Shell breaking strength decreased with hen age. Shell weight generally increased in a manner similar to egg weight but, for some flocks, tended to decrease later in lay. Shell thickness was relatively stable across a range of hen ages. Percentage shell was relatively constant until 60 weeks of age after which it tended to decrease. Albumen height and Haugh Unit generally decreased with increasing age of the flock and were more variable for the values measured in the laboratory owing to varying lengths of time elapsing between egg collection and measurement. Yolk colour varied between 8 and 13 and was independent of hen age (although two barn flocks from VIC were well below the average).

4.3 State Effects

There was generally no difference among states for the egg quality variables measured: egg weight; albumen height and Haugh Unit (both on-farm and laboratory); shell reflectivity (although three free range flocks from SA had significantly higher shell reflectivity; shell deformation (higher values for some flocks from QLD may be related to different laboratory technique); shell breaking strength; shell weight; shell thickness (although some individual flocks in NSW were below average); shell thickness (higher values for some of the QLD flocks may be associated with different laboratory practice and some flocks from NSW were below average); percentage shell; yolk colour.

4.4 Strain Effects

The relationship between egg weight and hen age was similar for all strains.
Albumen height measured on freshly collected eggs declined with hen age for all strains but was generally highest for the HyLine Brown and lowest for the HiSex birds. Haugh Unit, which takes into account the size of the egg, declined with hen age but was more similar among strains of bird than was albumen height for freshly collected eggs. There was a greater variability in both albumen height and Haugh Unit measured in the laboratory owing to different ages of the eggs. There was considerable overlap among strains for shell reflectivity. Three free range flocks, two HyLine and one HiSex had significantly lighter shell colour. Shell deformation was higher for some flocks from QLD which may be related to different laboratory technique in the QDPI&F laboratory. Shell breaking strength showed a considerable degree of overlap, but some flocks were noticeably below the average. Shell weight was generally highest for ISA and lowest for HyLine. There was no consistent difference among strains for shell thickness. Percentage shell was generally similar for all strains. Albumen height and Haugh Unit measured in the laboratory showed considerable variation because of the different amounts of time that had elapsed between the collection of the eggs and their analysis in the laboratory. For yolk colour, two barn flocks from VIC were well below the average.

4.5 Production Effects

There were no differences among production systems for egg weight; albumen height and Haugh Unit; shell breaking strength, shell thickness; percentage shell and yolk colour score. However, there were two barn flocks which had very low yolk colour score. Shell reflectivity was generally higher for free range flocks with several flocks well above average. Shell deformation was higher for flocks whose eggs were analysed at QDPI&F which may reflect different laboratory technique. With the exception of these eggs, there were no differences among production systems. Shell weight was generally higher for ISA than for the other two strains.
Yolk score was independent of hen age and production system.

4.6 Differences in albumen quality measured at the cage front and later in the laboratory

Albumen height was higher when measured on-farm than when measured at varying time intervals later in the laboratory. Haugh Unit was higher when measured on-farm than when measured later in the laboratory. When the loss in Haugh Units with time between on-farm analysis and analysis later in the laboratory are plotted on a graph, it can be seen that, for most flocks, there is a loss of Haugh Unit but, for other flocks, Haugh Unit was actually higher when measured in the laboratory. In general, the loss of Haugh Units was between 1 and 10 up to 15 days between analyses and between 10 and 20 for longer time delays between analyses.

4.7 Comparison with 2003 Study

Egg weight in the 2009 study is generally lower than for the 2003 study. Egg shell colour measured in the 2009 study was generally darker (lower reflectivity) than for the 2003 study, with the exception of the three free range flocks, mentioned earlier. Shell deformation measured in the 2009 study tended to be lower than for the 2003 study. Shell breaking strength was very similar for the two studies. Shell weight was very similar for the two studies. Shell thickness tended to be higher for the 2009 study. Percentage shell was very similar for the 2003 and 2009 studies. Albumen height measured in the laboratory in 2003 was generally higher than that measured in the laboratory in 2009. Albumen height measured in the laboratory in 2003 and on-farm in 2009 was very similar for the two studies. Haugh Unit measured in the laboratory in 2003 was similar to that measured in the laboratory in 2009. Haugh Unit measured on-farm in 2009 tended to be higher than that measured in the laboratory in 2003.

4.8 Variation within flocks

The extent of variability within a flock varied from relatively low for egg weight to relatively high for shell breaking strength and shell deformation. There was generally no clear correlation between the extent of variation and hen age.

4.9 Comparison against arbitrary standards

The findings of this study have been compared against arbitrary standards for some variables. However, again, there is considerable variation amongst flocks of similar ages. It would be very useful to industry to have cut-off values for what constitutes a good egg and what indicates an egg of inferior quality. However, the extent of the variation that occurs within individual flocks makes the development of such arbitrary values problematic.

General Conclusions

In general, egg shell quality and egg internal quality were relatively independent of state, strain of bird and egg production system although there was a range of values for all parameters measured. When flocks from different states were compared, several free range flocks from SA had lighter coloured shells, some QLD flocks had higher shell deformation and shell thickness and some NSW flocks were significantly below average for shell thickness. When the three strains of bird were compared, there were some differences. Albumen height of freshly measured eggs was generally highest for HyLine and lowest for HiSex although much of this could be explained by differing egg weights and there was less variation among strains for Haugh Unit. A small number of flocks, including three free range flocks, had lighter coloured shells. The cause of this reduced pigmentation is not known although suggestions include anaemia (Juergen Lohr, personal communication). The two barn flocks that had very low yolk colour appear not to have had pigment added to the feed. There were relatively few differences among production systems. As expected, albumen height and Haugh Unit measured later in the laboratory were generally lower than those measured directly at the cage front. However, watery whites were encountered only rarely and not consistently throughout a flock. This finding suggests that there is not a major problem with water albumen in Australian layer flocks. Comparison of the results of the 2009 study with those obtained in 2003 reveal some general differences with egg weight being lower, egg shell colour darker, shell deformation lower and shell thickness higher in the 2009 study.

Recommendations

It is clear from the results of this study that some producers have flocks that are performing towards the top of the range, others are towards the bottom of the range whereas some are more-or-less in the middle of the pack. Further understanding of the factors that influence the performance of individual flocks will assist in developing more specific guidelines to ensure good egg quality.

References

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Roberts, J.R. 2008. Egg shell quality: Any better, any worse? Proceedings of the World's Poultry Congress, Brisbane 2008. On CD-ROM (available from author).

Roberts, J.R. and W. Ball. 2004. Egg Quality Guidelines for the Australian Egg Industry. AECL Publication No. 03/19 (AECL Project UNE 71-A).

Appendix 1

AECL Egg Quality Project "Egg quality testing and identification of quality risk factors"

Questionnaire

Details of laying flock sampled

Farm

Owner:..........

Address:..........

Contact person:..........

Phone:..........

Fax:..........

Email:..........

Date:..........

Farm capacity layers:..........

Water source (e.g. Reticulated, dam, stream, bore, well):..........

If not reticulated, what treatment does the water undergo?..........

....

Flock details

Shed No:..........

Flock No:..........

Breed and generation of bird:..........

Age of flock/hatch date:..........

Housed in Single age/multi-age shed:..........

Controlled environment or natural ventilation housing:..........

Production system; cage, barn, free range:..........

Egg production

Age at first egg:..........

Age at peak production:..........

Age at 90% after peak production:..........

Egg collection - daily or days per week:..........

Egg cooling - cooled before packing/grading or after packing/grading:..........

....

Type of egg fillers used..........

Refrigeration of eggs (type, temperature, humidity)..........

....

IB vaccination / ages vaccinated:..

Have you had birds in the flocks with a cough or snicker during the last 12 months?...

Has IB been diagnosed or suspected to have occurred in any flocks during the last 12 months?:...

Are there calcium splashes on the eggs?...

How many years experience do your staff have?...

....

Is your farm audited by the grading agents...

Additional Information required if problem solving is required due to poor quality:

Distance from nearest poultry farm..

Type of feed (including formulation if available)..

Feed enzymes (or not), and type...

Rearing conditions/history including vaccination protocols..

Water source including analysis if available...

Egg mass..

Body weight...

Lighting..

Housing type..

Mortalities..

Egg collection procedure (e.g. on farm processing, transportation to another site for processing)..

Yolk pigmenter used?...

Maize or Lucerne in diet?..