BODY WEIGHT UNIFORMITY AND EGGSHELL QUALITY OF HENS IN A FREE-RANGE PRODUCTION SYSTEM

E.K. SUAWA[1], J.R. ROBERTS[1] and G. PARKINSON[2]

Summary

Birds from seven flocks of commercial free-range hens were weighed at the ages of 19, 26, 37, 50 and 60 weeks. Body weight increased with increasing hen age for all flocks. Flock uniformity varied among the ages and flocks, being most consistent in flocks 1 and 6. Eggs were collected from the flocks at the ages of 19, 26, 37, 50 and 60 weeks. Traditional egg quality measurements were determined using specialized equipment supplied by TSS UK. There was a significant effect of flock age for all egg quality measurements. With advancing hen age, egg weight increased and shell weight, percentage shell, shell thickness and yolk colour varied, whereas shell breaking strength, shell deformation, albumen height and Haugh units decreased. Cuticle cover was measured using MST cuticle stain and a hand-held Konica Minolta spectrophotometer. Cuticle cover varied with hen age, being highest at 37 weeks of age for all flocks combined. For all ages combined, cuticle cover was highest for flock 6. Maintaining high flock uniformity results in improved eggshell quality

I. INTRODUCTION

Apart from strain, nutrition and disease, body weight uniformity is another factor that may influence overall egg quality. Maintaining high body weight uniformity is a major objective during the rearing period, and provides an estimate of the variability in a given flock at a given age. The more uniform the flock, the better the performance of that flock, and the more consistent the nutritional responses of a given flock. The conventional goal for flock uniformity is to have 80 per cent of the pullets within plus or minus 10 per cent of the average flock body weight. Flocks with high uniformity have been reported to reach peak egg production earlier and have higher peak production than flocks with low uniformity (Hudson *et al*., 2001; Kosbah *et al*., 2009). On the other hand, poor uniformity is associated with variation in the degree of sexual maturity of hens, and underweight pullets have delayed onset of egg production (Yuan *et al*., 1994).

Problems that develop during the growing period cannot easily be corrected after egg production begins. It has been generally assumed that flock uniformity is more difficult to achieve in free range production than in cage production and these differences between conventional cage performance and free range seem likely to respond to additional research that defines the mechanisms for the performance differences.

II. MATERIALS AND METHODS

Seven flocks of Hy-Line Brown commercial layers (FR1-7), in commercial free-range production in NSW, were followed throughout the production cycle. At least 100 birds were weighed from each flock at different ages: 19, 26, 37, 50 and 60 weeks of age and body weight uniformity was calculated.

A total of 90 eggs was collected from each flock at 26, 37, 50 and 60 weeks of age. Thirty eggs were processed for the amount of cuticle with MST cuticle blue stain. A hand-held Konica Minolta spectrophotometer (CM-2600d) was used to measure the cuticle colour.

[1]Animal Science, SERS, University of New England, Armidale, NSW 2351; jrobert2@une.edu.au
[2]Livorno Consulting, 86 Wilson St., Brunswick, VIC 3065.

The colour of the eggshell cuticle, stained with MST cuticle blue dye was measured using the L*a*b colour space. L* has a maximum of 100 (white) and a minimum of 0 (black). Green is indicated by –a* and red by +a*. Blue is indicated by –b* and yellow by +b*. ΔE^*_{ab} was calculated as described by Leleu et al. (2011). Sixty eggs were used for determination of traditional egg shell quality measurements: shell reflectivity, egg weight, eggshell breaking strength, shell deformation, shell weight and shell thickness, using specialized equipment (Technical Services and Supply, TSS, UK). Egg internal was also measured in the form of albumen height, Haugh Units and yolk colour. The extent of cuticle cover and ultrastructural features of the mammillary layer were also analysed.

Data were analysed using Statview Software (SAS Institute Inc., Version 5.0.1.0). A two way analysis of variance was conducted taking flock age and flock as the independent variables and body weight, egg quality measurements, SCI a* after staining and single score (ΔE^*_{ab}) as dependent variables. Level of significance was indicated by probability of less than 5%. The Fishers PLSD test was used to differentiate between mean values.

III. RESULTS

There was a significant difference among flocks for body weight at all ages recorded (Table 1) and body weight increased as hens aged. At 19 weeks of age, FR 1, FR2, and FR 5 were about 150 g below the breed standard, whereas FR 6 was 120 g above breed standard. At 60 weeks of age, only two flocks (FR2 and FR5) had reached the breed standard body weight of 1.96 kg.

Table 1 - Flock body weight in free-range systems from age 19 weeks to 60 weeks.

Flocks	Hen age (weeks)					Flock Uniformity (%)				
	19	26	37	50	60	19w	26w	37w	50w	60w
FR 1	1.45±0.01[c]	1.89±0.02[a]	1.97±0.02[a]	1.95±0.02[ab]	1.92±0.02[bc]	80.9	83.7	85.5	81.3	75
FR 2	1.48±0.01[c]	1.78±0.02[b]	2.0±0.01[a]	1.94±0.02[ab]	1.96±0.02[b]	80	79.1	72.2	78	76
FR 3	1.68±0.01[a]	1.86±0.01[a]	1.92±0.02[b]	1.98±0.02[a]	2.03±0.02[a]	77.5	84.9	76.7	78.9	79.4
FR 4		1.81±0.02[b]	1.92±0.01[b]	1.94±0.01[ab]	2.0±0.02 [ab]	-	74	74.4	81.8	73.8
FR 5	1.48±0.01[c]	1.72±0.01[c]	1.77±0.01[d]	1.96±0.02[ab]	1.97±0.02[b]	68.2	83.1	77.4	80.4	77.3
FR 6	1.72±0.01[a]	1.85±0.01[a]	1.86±0.01[c]	1.91±0.02[b]	1.89±0.02[cd]	83.5	84.2	80	81	80.8
FR 7	1.62±0.01[b]	1.87±0.02[a]	1.84±0.02[c]	1.87±0.01[c]	1.86±0.01[d]	79.4	76.3	73.3	81	84.3
Breed std.	1.6	1.86	1.92	1.95	1.96					
P	<0.0001	<0.0001	<0.0001	0.0001	<0.0001					

[a,b,c,d] within a column, values with different superscripts are significantly different from each other. Values are Mean ± SE

Body weight uniformity of the flocks studied ranged from 62 to 89% (Table 1). There was no clear pattern of body weight uniformity in relation to flock age. Flocks 1 and 6 maintained high uniformity between 19 and 50 weeks of age, relative to the other 5 flocks.

There were significant main effects ($P<0.0001$) of hen age (Table 2) and flock ($P<0.0001$) for all eggshell quality measurements. As hen age increased, egg weight increased; translucency, shell reflectivity, shell weight, percentage shell, shell thickness and yolk colour fluctuated; shell breaking strength, deformation, albumen height, and Haugh units decreased; shell reflectivity varied significantly among the age groups being lowest at 26 weeks of age. There was a significant difference among the flocks for egg shell and egg internal quality measures, with variation in albumen height, Haugh Unit and yolk colour score.

Table 2 - Effects of hen age on the traditional measures of egg shell quality.

Measurement	Hen age (weeks)				P Value
	26	37	50	60	
Egg shell quality:					
Translucency score	3.80±0.05[a]	3.47±0.05[b]	3.31±0.05[c]	3.57±0.05[b]	<0.0001
Shell reflectivity (%)	28.01±0.20[c]	30.54±0.22[a]	29.85±0.27[b]	30.97±0.24[a]	<0.0001
Egg weight (g)	58.66±0.21[c]	61.68±0.22[b]	63.47±0.24[a]	63.26±0.25[a]	<0.0001
Breaking strength (N)	44.14±0.41[a]	43.52±0.39[a]	42.01±0.35[b]	40.32±0.39[c]	<0.0001
Deformation (μm)	292.95±3.93[a]	287.19±2.31[a]	269.41±1.73[b]	260.74±2.05[c]	<0.0001
Shell weight	5.57±0.03[d]	5.77±0.03[c]	6.05±0.03[a]	5.96±0.03[b]	<0.0001
Percentage shell (%)	9.51±0.04[a]	9.37±0.04[b]	9.54±0.04[a]	9.45±0.04[ab]	0.0018
Shell Thickness (μm)	401.07±1.44[b]	404.19±3.73[b]	415.80±3.73[a]	407.89±1.32[b]	0.0001
Internal quality:					
Albumen height (mm)	8.96±0.06[a]	7.11±0.06[b]	6.87±0.07[c]	6.33±0.07[d]	<0.0001
Haugh Units	94.52±0.28[a]	83.11±0.41[b]	80.92±0.45[c]	76.99±0.52[d]	<0.0001
Yolk colour score	10.32±0.05[b]	9.99±0.06[c]	10.41±0.05[ab]	10.46±0.05[a]	<0.0001

There was a significant difference among age categories for a* after staining for cuticle cover. Means values for a* increased, with the most negative values at 37 weeks of age and was confirmed by single value ΔEab.

Table 3 - Spectrophotometric measurements of stained cuticle.

Measurement	Hen age (weeks)				P Value
	26	37	50	60	
a*	1.51±0.34[a]	-0.65±0.36[b]	-0.09±0.42[b]	0.05±0.39[b]	<0.0001
ΔEab	18.52±0.43[b]	19.92±0.39[a]	18.75±0.45[b]	17.37±0.44[c]	<0.0001

[a,b] Across a row, values with different superscripts are significantly different from each other. Values are Mean ± SE

IV. DISCUSSION

In this experiment, flock uniformity was not consistent within individual flocks across the ages sampled. FR1 had a lower pullet weight at 19 weeks, and the average growth rate between 19-37 weeks of age complied closely with the breed standard and maintained high uniformity between 19 and 50 weeks of age. For FR 6, on the other hand, pullet body weight at 19 weeks was 120 g above the breed standard and was lower than the breed standard at 37-60 weeks of age. However, FR 6 maintained 80% uniformity at the ages sampled. The poor performance of many of the other flocks illustrates the likely variation at a commercial level; poor compliance with average growth rates patterns and low uniformity standards.

Age has an important effect on egg shell and internal quality. With increasing hen age, egg weight, shell weight and yolk colour increased. On the other hand, shell breaking strength, shell deformation, percentage shell and albumen height decreased, which is in agreement with previous studies (Roberts and Chousalkar, 2012; Van Den Brand et al., 2004).

The results of this experiment demonstrated a significant interaction between flock uniformity and egg quality parameters. FR 6 was very consistent for flock uniformity and this flock also had higher shell breaking strength, shell weight, percentage shell, shell thickness and amount of cuticle cover. Body weight at point of lay is a major factor influencing subsequent growth, production, and egg size (Balnave, 1984) and may influence flock uniformity during egg production. Maintaining flock uniformity is very important for achieving good egg shell quality. Fiks-Van Niekerk (2005) reported that egg quality of non-cage eggs is very variable, possibly due to higher environmental variation which leads to more factors contributing to egg quality.

The results from a*value after staining with cuticle blue dye was lower at 37, 50 and 60 weeks of age as compared with 26 weeks, indicating that the mean cuticle cover on the shell was lowest at 26 weeks. The single score value showed a strong correlation with the a* value (R^2 = 0.8644). Sparks and Board (1984) stated that cuticle thickness decreases significantly with increasing age of the hen. However, Roberts, Chousalkar and Samiullah (2013) found that there was no significant effect of flock age in a conventional cage production system on the extent of the cuticle cover. The cuticle is thought to play a role in controlling water exchange by repelling water or preventing its loss, and may function in limiting microbial colonization of the eggshell surface (Hincke *et al*., 2008). Together with the mineralized shell and shell membranes, the cuticle constitutes a physical barrier against microorganism invasion and contamination of the egg content. (De Reu *et al*., 2008).

It seems likely that the lower average body weight in free range flocks will result in lower average egg weights, and this may confer some advantages for shell quality. Body weight at point of lay does affect the overall eggshell quality. However, maintaining flock uniformity is more important for good eggshell quality.

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