EFFECT OF GENOTYPE, AGE OF LAYER AND THEIR INTERACTION ON EGG QUALITY CHARACTERISTICS OF EGG-LAYER CHICKENS

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ABSTRACT

A study was carried at the Papua New Guinea University of Natural Resources and Environment to evaluate the effects of genotype and age of laying bird on egg quality traits of egg-layer chickens. A total of 180 eggs were collected from three genotypes at 56 and 68 weeks of age. The three genotypes were Australorp and F_1 and F_2 crosses derived from crossing an Australorp sire line with the Shaver Brown commercial dam line. Thirty eggs from each genotype and age group were evaluated for external and internal egg quality characteristics. The traits measured were egg weight (EW), egg shape index (ESI), shell weight (SW), shell percentage (SP), yolk weight (YW), yolk percentage (YP), albumen weight (AW), albumen percentage (AP), albumen height (AH) and Haugh unit (HU). The effects of genotype were found to be significant ($P<0.05$) for ESI, SW, SP, YW and YP. The highest value for ESI was for the F1 and shell quality was better for the crosses than for the Australorp. By contrast, the Australorp had the highest yolk percentage of 28.77 percent compared to 27.86 and 27.30 percent for the F1 and F2 respectively. Egg and yolk weights increased significantly ($P<0.05$) by three and four percent respectively with increased age. Albumen quality was not influenced by differences in genotype and age. However, a genotype by age interaction was observed for AW, AP and YP. The Australorp had high AW and AP initially but these declined with increasing age compared to the crosses. The F1 had the highest YP in the beginning but the Australorp had the highest YP by week 68. The results suggest that differences in genotype and age of bird, and their interaction, may affect egg quality traits of layer chickens. Customers who buy crossbred eggs of the same weight would obtain less yolk than those who buy Australorp eggs.

Key words: genotype, age, egg quality, egg-layer chickens

INTRODUCTION

Improving egg production in Papua New Guinea (PNG) through developing low cost feeds and improving available chicken-types through crossbreeding is an ongoing program of the National Agricultural Research Institute and other stakeholders. This is to help provide alternative feed and chicken types for farmers who are often faced with problems of commercial feed and chick replacements being either too expensive or not accessible, especially in the island provinces.

Work done by the current authors (Jambui and Quartermain 2012) on the productivity of Australorps and their crossbreds with commercial Shaver Brown layers have shown that the crosses are more efficient in growth and egg production than the Australorp. In terms of egg quality assessment, Australorps had higher yolk color values than the crosses although there were no differences in shell thickness among the genotypes. Egg weight was higher for the crosses. Kobila (2012) also found the crosses to be more efficient in converting feed into egg weight and number.

Monitoring egg quality characteristics of egg-layer chickens is important in terms of production economy. This is because the economic success of a laying flock depends on the num-

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ber of high quality eggs produced. Egg quality may be divided into external factors, including egg weight, specific gravity and egg shell quality, and internal factors, including yolk quality, albumen quality and egg air-cell determination. These characteristics are influenced by a number of genetic and non-genetic factors including breed, age of hens, length of storage and season.

Genotype and age are two important factors that influence egg quality. Brown hens lay heavier eggs than white ones. The eggs are larger and have less yolk, more albumen and a greater percentage of shell than those from white hens (Heil and Hartmann 1997; Silversides and Scott 2001). Furthermore, Levendecker et al. (2001) showed significantly higher yolk weight in white egg chickens (Lohmann LSL) in comparison with the brown Lohmann Tradition. Moreover, other comparisons have shown that the Rhode Island Red breed and other brown egg strains, including commercial layers, have better albumen quality than the leghorn breed or other white egg strains (Knox and Godfrey 1934; Nordskog and Cotterill 1953). On the other hand, Tůmová et al. (1993) found significantly higher yolk weight and percentage in Hisex Brown with brown eggs than in D-29 with white eggs. Another study by Marion et al. (1964) reported that when eggs were divided within strain into large and small weight classifications, the larger eggs had less percentage yolk and more percentage albumen than smaller eggs. Genetic groups with larger egg size have less yolk and more albumen compared to groups laying smaller eggs.

The main differences in eggshell quality are between the white and brown egg laying hens. For instance brown egg layers D 102 had a higher shell weight in comparison with lines of White Leghorn (Ledvinka et al. 2000). In contrast, Basmacioglu and Ergul (2005) did not report a significant effect of the genotype on shell percentage and thickness. Brown eggs had a thicker eggshell than the white ones in one report (Silversides and Scott 2001) but Knox and Godfrey (1934) and Nordskog and Cotterill (1953) found a thinner shell in brown eggs. Egg Shape Index in the white hens Shaver Starcross 288 was higher than in the brown Moravia SSL (Halaj and Grofík 1994).

For albumen height, genotype plays a major influence (Ashraf et al. 2003; Scott and Silversides 2000) and results from the latter author showed that height of the inner thick albumen of the eggs from ISA-White hens was greater than in eggs of the ISA-Brown hens. On the other hand, Levendecker et al. (2001) found significantly higher values for Haugh Units in white layers than in brown hens.

Many studies on the effect of genotype on egg quality have compared differences between brown and white eggs from layers. However, the differences between layers are not due to a direct relation with egg shell color but rather due to differences in the genetic origins of the hens. Furthermore, results from Zhang et al. (2005) indicated that eggshell color had little, if any, relationship to external or internal egg quality. Thus the color of the egg is not associated with the quality of the egg.

Age of hen is another factor that influences egg weight. Studies by Silversides and Scott (2001), Van den Brand et al. (2004), Zita et al. (2009), and Baumgartner et al. (2007) showed that egg size increased with increasing age of the hen. On the other hand, Zemková et al. (2007) demonstrated that the egg weight was not influenced significantly by age. The age of hens also increased yolk weight (Van den Brand et al. 2004; Zita et al. 2009; Rossi and Pompei 1995; Suk and Park 2001), albumen weight (Zita et al. 2009; Rossi and Pompei 1995; Suk and Park 2001) and yolk proportion (Zita et al. 2009; Rossi and Pompei 1995; Rizzi and Chiericato 2005) but decreased albumen percentage (Van den Brand et al. 2004; Zita et al. 2009), egg shell percentage (Silversides and Scott 2001; Zita et al. 2009) and shape index (Van den Brand et al. 2004).

Numerous studies have also shown that Haugh Unit and albumen height decreases with age (Silversides and Scott 200; Ashraf et al. 2003; Atkan 2011). That is to say that the albumen height (thick albumen) was run down by the increasing age, even though egg weight and total amount of albumen increase. Younger hens had higher values of Haugh unit than older hens.

Not much work has been done in PNG up to now on egg quality of the available egg-layer chickens. Hence this study was carried out to assess the effect of genotype and age on egg quality characteristics of the Australorp (A), and its crosses F_1 (A x Shaver) and F_2 (F_1 xF_1).

MATERIALS AND METHODS

The study was carried out in 2011 at the University of Natural Resources and Environment (Vudal campus) located at152°00E and 04°21S with an elevation of 55 m above sea level. The mean annual rainfall is 2200 mm and mean annual minimum and maximum temperatures are 23 ^{0}C and 32 ^{0}C.

Six groups of birds were used in this study of which there were three genotypes and two age groups. Each group of birds had 20-25 hens. The genotypes were Australorp, F1 and F2 crosses. The F1 cross is a cross between Australorp roosters and Shaver Brown hens while the F2 is the result of crossing F1 by F1. There were two age groups per genotype, one of 56 weeks old and the other of 68 weeks.

On average, six freshly laid eggs were randomly collected each day for the six groups, for a period of five days. The eggs were transferred soon after being collected at the University poultry farm to the science laboratory to break and analyze. A total of 30 eggs were analyzed for each of the three genotypes in the two age groups giving a grand total of 180 eggs analyzed. Egg colors ranged from tinted white for Australorp to those of the F1 and F2 crosses which laid eggs that were of different shades of brown to light brown and tinted white.

The dependent variables measured were egg weight (EW), egg shape index (ESI), shell weight (SW), shell percentage (SP), yolk weight (YW), yolk percentage (YP), albumen weight (AW), albumen percentage (AP), albumen height (AH) and Haugh Unit (HU).

The eggs were numbered and weighed on a sensitive scale to the nearest 0.1 g. The width and length of each egg were measured using a vernier caliper (Smiec 0-150 x 0.02 mm) to determine egg shape index. Each egg was broken and its contents poured onto a flat white plate in order to measure the albumen height. Albumen height was measured as the height of the chalazae at a point midway between the inner and outer circumference of the white using an AMES micrometer. The yolk was separated from the albumen and then weighed, while the albumen weight was detected by subtracting the weights of yolk and eggshell from egg weight. Shells were weighed on the sensitive scale to the nearest 0.1 g after each egg was broken.

Other egg quality parameters were estimated using the following formulae:

Egg shape index = [length (cm)/width cm)] x 100 (1)

Albumen percentage = [albumen weight (g)/egg weight (g)] x 100 (2)

Yolk percentage = [yolk weight (g)/ egg weight (g)] x 100 (3)

Shell percentage = [egg shell weight (g)/egg weight (g)] x 100 (4)

Haugh Unit = 100 log (H+7.57 - 1.7 $W^{0.37}$) (5)

Where:

H = height of albumen
W = egg weight (grams)

DATA AND SOFTWARE ANALYSIS

Statistical analysis of the data on egg quality was performed using Genstat Discovery Edition 3 software by two-way analysis of variance. The model included the main effects of genotype and age and their interaction. Significant differences between means were determined by Least Significant Difference (LSD) at a level of $\alpha = 0.05$.

RESULTS

Tables 1 and 2 and Figures 1, 2 and 3 show the results obtained from this experiment. Interactions are shown graphically only for traits for which they were significant.

DISCUSSION

There were significant genotypic differences in external egg quality traits for shell weight, shell percentage and egg shape index but not for egg weight. SW and SP were significantly higher for both crosses, F1 (7.68g, 11.3%) and F2 (7.73g, 11.8%) than for Australorp (7.21g, 11.3%).

Egg shape index was significantly higher for the F1 cross (75.22%) compared to the Australorp (71.87%) and F2 cross (70.74%). An index of 74 percent is considered optimal and a variation between 72-76 percent is satisfactory. It can be seen that the narrower or longer the egg the lower the index. Thus the egg shape index of the F1 is satisfactory whilst

Table 1: The effect of genotype and age on external egg quality traits

Genotype	EW (g)	ESI (%)	SW (g)	SP (%)
Australorp	63.77±0.53	71.87±0.50a	7.21±0.13a	11.3±0.17a
F1	65.20±0.64	75.22±1.05b	7.68±0.11b	11.81±0.16b
F2	63.31±0.77	70.74±0.44a	7.73±0.15b	12.21±0.17b
Age				
55 weeks	63.10±0.60a	72.58±0.68	7.46±0.11	11.84±0.13
68 weeks	65.08±0.45b	72.64±0.55	7.62±0.10	11.70±0.15
Source of variation				
Genotype	NS	*	*	*
Age	*	NS	NS	NS
Genotype x Age	NS	NS	NS	NS

*P≤0.05

eggs of the Australorp and F2 are sharper i.e. shape index ranged less than 72 percent. There was no difference in the external egg qualities studied as age of birds increased except for EW. Yannakopoulos et al. (1994) also did not find significant differences by age for egg shell characteristics. EW increased from 63.10g at 56 weeks to 65.08g at 68weeks. This is similar to findings by Silversides and Scott (2001), Van den Brand et al. (2004), Zita et al. (2009), Baumgartner et al. (2007) and Ketelaere et al. (2002) who noted increasing egg weight with increasing age.

The quality of albumen is given by AW, AP, AH and HU in Table 2. None of these variables were affected by genotype and age of hens. AW ranged from 38.26g – 39.37g, AP from 59.98 - 60.47 percent, AH from 7.77 - 8.14 mm and HU from 86.53 - 88.53 percent. The HU values fell within the preferred range of 72 - 100 mentioned by Izat et al. (1985).

However, significant interaction (p=0.05) was observed for AW and AP and the trend is shown in Figures 1 and 2. Although both AW and AP were initially higher for the Australorp at 56 weeks, the values declined so that by week 68 both crosses had higher values.

Yolk weight and percentage were significantly influenced by differences in genotype of hens. The Australorp and the F1 had higher YW of 18.3g and 18.15g than the F2 (17.26g). For YP, the Australorp had the highest YP (28.77%) compared to both crosses (27.86%

Table 2. The effect of genotype and age on internal egg quality traits

Genotype	YW (g)	YP (%)	AW (g)	AP(%)	AH (mm)	HU
Australorp	18.30±0.22a	28.77±0.30a	38.26±0.41	59.98±0.32	8.05±0.17	88.05±0.94
F1	18.15±0.24a	27.86±0.30b	39.37±0.49	60.33±0.33	8.14±0.16	88.53±0.85
F2	17.26±0.21b	27.33±0.26b	39.32±0.55	60.47±0.28	7.77±0.18	86.53±0.99
Age						
56 weeks	17.53±0.20a	27.80±0.26	38.11±0.44	60.36±0.26	7.93 ±0.14	87.62±0.79
68 weeKs	18.28±0.16b	28.14±0.22	39.19±0.35	60.16±0.26	8.04 ±0.13	87.79±0.73
Source of variation						
Genotype	*	*	NS	NS	NS	NS
Age	*	NS	NS	NS	NS	NS
Genotype x Age	NS	*	*	*	NS	NS

*P≤0.05

Figure 1. Genotype and age interaction on Albumen weight

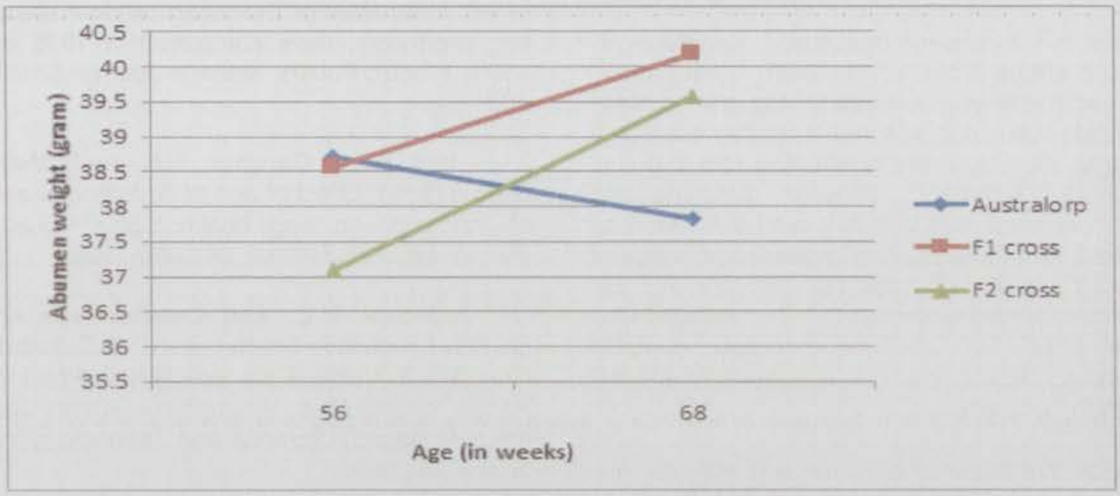
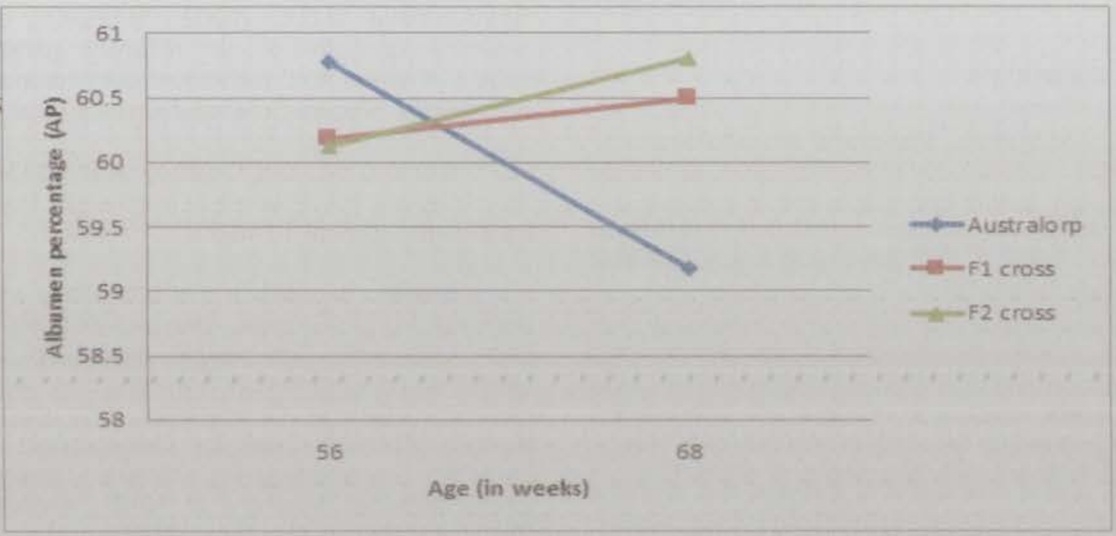


Figure 2. Genotype and age interaction on Albumen Percentage



and 27.33%). Significant interaction between genotype and age was found for YP as shown in Figure 3. The F1 cross had the highest YP of 28.10 percent at week 56 but by week 68 the Australorp had the highest YP of 29.5 percent. The trend seems to be that YP was increasing for the Australorp over time while it was decreasing for both crosses.

Generally, both crosses had less yolk, more albumen and greater shell percentage. This is similar to the results of Silversides and Scott (2001). The results from the crosses indicate that genetics contributed to the results showing similar trends to brown egg strains, as one of the parents is the Shaver Brown. Brown egg strains have better albumen quality than the leghorn or white strains. In the Australorp, YP increased with the age of hen as AW and AP declined. SW and SP were also low. These results for the Australorp are similar to findings from white egg strains and may relate to the genetic background of the Australorp developed from the Black Orpington. It is not the color of the egg that influences egg quality but rather the genetic background of the hen.

YW significantly increased with age from 17.53g at 56 weeks to 18.28g in week 68. One likely explanation is that, since egg weight influences the weight of its components, when EW increases with age so does yolk weight. Other studies that support the influence of increased age on increased yolk weight include Zita et al. (2009), Rossi and Pompei (1995) and Suk and Park (2001) .

CONCLUSIONS

From the results of this study, genotype affected shape index, shell weight, shell proportion and yolk characteristics. Albumen characteristics were not affected by either genotype or age. Age significantly affected egg and yolk weights. Interactions between genotype and age occurred for YP, AW and AP. As egg weight for the Australorp increases with age of hen, YP also increases but AW and AP decrease. On the other hand, YP is reduced with age while AW and AP increase for both crosses. The Australorp had lower SW and SP than the crosses.

The percentages of albumen and yolk are important to the egg breaking industry. Breakers who buy eggs of the crosses would obtain less yolk than those who purchase Australorp eggs.

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