PROCESSING AND PRODUCTS

Comparison of Physical Quality and Composition of Eggs from Historic Strains of Single Comb White Leghorn Chickens

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ABSTRACT The effect of long-term genetic selection on physical quality and composition of eggs was determined by analyzing eggs acquired from Agriculture Canada: Ottawa Control Strain 5 (CS5) from a 1950 base population, 7 (CS7) from a 1958 population and 10 (CS10) from a 1972 population. Eggs from the H&N "Nick Chick" current commercial strain (CCS) were also included. Eggs were collected monthly over a 62-wk laying period and analyzed for egg, albumen, shell and yolk weight; albumen protein, solids and pH; percentage yolk solids and fat; Haugh units; and specific gravity.

Significant ($P < 0.05$) differences found between strains included a progressive increase in weight of eggs from the CS5 to CCS. Although the eggs increased in size, no significant differences were found between strains for specific gravity or percentage shell weight. Yolk weights of eggs from the strains examined did not differ. However, the percentage of yolk found in current strain eggs was significantly lower ($P < 0.05$), with a subsequent higher percentage albumen due to the increase in egg size of the CCS. Haugh units were significantly higher in the CS10 and CCS strains than in the other strains. No significant differences between strains were seen in albumen protein, solids, pH, or yolk solids. Mean percentage yolk fat assay values for eggs from the CS5, CS7, CS10, and CCS strains were 33.08, 32.68, 32.84, and 32.40, respectively. Percentage yolk fat values obtained from CCS were significantly lower ($P < 0.05$) than those obtained from the other strains. The results from this study indicate that genetic selection has produced larger eggs containing a lower percentage of yolk while overall egg quality has been maintained or improved.

(*Key words*: historic strains, egg quality, layer)

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INTRODUCTION

Improvements in the management, disease control, nutrition, and genetics of layers as well as advancements in processing technology over the past 40 yr have undoubtedly changed egg quality and composition, yet few studies have documented this progress. Cook and Briggs (1977) cited several studies that show breed, strain, and age of hens directly influence the size and composition of eggs. Significant differences in percentage yolk and albumen in lines of White Leghorns with genetically different egg sizes were found by Marion *et al.* (1964). The proportion of yolk tended to be greater and the proportion of albumen smaller in small eggs than in larger eggs. They concluded that egg size accounted for most of the differences in proportion of yolk, albumen, and total albumen solids. Further research has been conducted to investigate the heritability of egg compositional traits and their relationship to egg size. Abplanalp *et al.* (1984) showed that some highly heritable differences in egg composition between inbred lines and their crosses, such as percentage yolk, were not related to egg size. Comparisons of egg compositional traits from unselected control strains and commercial strains have indicated that eggs from selected commercial strains weighed more and contained higher percentages of albumen, albumen solids, and albumen protein than control strains (Rodda *et al.*, 1977). The existence of genetic group or strain differences in albumen percentage solids and albumen protein has also been reported (May and Stadleman, 1960; Rose *et al.*, 1966). However, this variation among strains has often been related to variation in egg size. A positive genetic correlation between egg weight and the proportion of solids in albumen was also cited by Akbar *et al.* (1983) and Hill *et al.* (1966).

Many workers have reported an age effect on egg size and composition traits. Most of these trends can be reversed by forced molting, but resume afterwards. Eggs

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Abbreviation Key: CCS = current commercial strain; CS = control strain.

increase in weight over a production period. This increase is associated with development of both yolk and albumen constituents, although such changes occur disproportionately, with the percentage yolk progressively increasing while the percentage albumen decreases. Izat (1983) and Cunningham *et al.* (1960) found that percentage of albumen solids, albumen protein, and Haugh units decreased with age of bird. Both studies reported that as hens age the yolk quality traits generally improve, whereas the albumen traits worsen. This research project used the Ottawa randombred control strains to evaluate the influence of genetic selection on composition and physical quality factors of eggs.

MATERIALS AND METHODS

The three randombred control strains were composite representatives of the genetic stocks that were in use by the commercial egg industry over the past four decades. The current strain (H&N "Nick Chick" of 1993), was chosen because it has been under continuous selection since the early 1950s and shares some genetic ancestry with the three historic strains. The use of the randombred controls allowed direct comparison using equivalent modern laboratory equipment and methods.

Hatching eggs from three Ottawa randombred control strains: Control Strain 5 (CS5) obtained from a 1950 base population, Control Strain 7 (CS7) obtained from a 1958 population, and Control Strain 10 (CS10) based from a 1972 population, were acquired from Agriculture Canada, and were hatched together with the H&N "Nick Chick" strain, a current commercial strain (CCS). The three CS have been maintained using procedures designed to minimize genetic change. Gowe and Fairfull (1980) describe the Agriculture Canada stocks further. The four strains were brooded and reared in the same cage growing facilities with the same cage densities and nutritional program.

Initial samples were collected in June 1994 when the birds were 28 wk old. Subsequent samples of up to 220 eggs from each strain were collected monthly from the previous 24 h production. This time period included eggs collected before and after a 2-wk molting period that took place during the 9th mo. Approximately 3,300 eggs were evaluated over a 15 mo collection period. After collection, eggs were transported directly to the laboratory for specific gravity testing.

Mean specific gravity was determined by the California two brine flotation method (Mellor and Miller, 1976). A sample of 150 to 210 eggs from each strain was immersed in salt solutions of known specific gravities and the number of "floaters" and "sinkers" counted. Probability paper was used to determine the average specific gravity of each strain. After specific gravity measurements were taken, eggs were stored at 5 C overnight and broken out the following day. A 10 egg sample from each of the four test strains was randomly selected and weighed to the nearest 0.01 g. After breakout, Haugh units[2] (Haugh, 1937) were calculated and the yolks were separated and weighed. The albumen was collected into duplicate samples of five eggs from each treatment, stirred to mix, and pH measured immediately. A Fisher Accument Model 805 MP meter[3] was used to determine pH. The shells were rinsed and air-dried under a fume hood to constant weight and the shell weight recorded. Albumen weight was estimated as egg weight minus yolk weight minus dry shell weight. Separately pooled yolk samples and albumen samples from each strain were frozen for later chemical evaluation. For chemical analysis, the experimental unit was the pooled sample of yolk or albumen. For all other measurements, the experimental unit was the individual randomly selected eggs from each strain. Albumen solids were determined in duplicate by placing samples into a 105 C forced air oven and drying 24 h to a constant weight. Protein analysis was performed by the Kjeldahl nitrogen method (AOAC, 1990).

The CEM Fat/Moisture Analyzer[4] was used for determining percent yolk solids and fat from pooled yolk samples. After a sample is dried by microwave and weighed, the system implements a rapid solvent extraction with methylene chloride and calculates percentage fat from weight loss. This method was found to give similar percentage fat results but with more precision than a modified Folch method described by Maxwell *et al.* (1980).

Data were analyzed using the General Linear Models procedure (SAS Institute, 1987). The analysis utilized a split-plot design. Treatment means were compared by the LS Means test. The monthly time factor was used in the regression analysis to determine change in the egg associated with bird age.

RESULTS AND DISCUSSION

The mean values for the egg quality attributes measured over the 14-mo period are shown in Table 1. Period means for the four strains followed similar patterns. A progressive increase in egg weight was seen between strains. Increases were also seen in the weight of the shell and albumen components. A significant ($P < 0.05$) production period effect was also observed with egg weights increasing over time within all strains. This increase leveled off after the molt period (Figure 1). No significant differences in percentage shell or specific gravity were seen between the strains even with the increased egg size of CCS. Haugh units were significantly higher in the CS10 and CCS strains and Haugh measurements of all strains decreased significantly over the first 9 mo of production (Figure 2). Curtis *et al.* (1985) reported similar aging effects on interior quality

[2]Egg Quality Micrometer, B.C. Ames, Co., Waltham, MA 02254.
[3]Fisher Accument, Fisher Scientific, Pittsburgh, PA 15238.
[4]CEM Fat/Moisture Analyzer, CEM Corp., Matthews, NC 28105.

TABLE 1. Average values for egg quality measurements

Strain	Weight	Haugh units	Yolk weight	Albumen weight	Shell weight	Percentage shell	Percentage yolk	Percentage albumen	Specific gravity	pH	Percentage yolk fat	Percentage albumen solids	Percentage albumen protein	Percentage yolk solids	Percentage yolk protein
	(g)		(g)			(%)					(%)				
CS5	58.57[d]	67.70[c]	17.96	35.34[b]	5.28[c]	9.03	30.64[a]	60.33[b]	1.082	9.12	33.08[a]	11.90	10.32	51.53	15.82
CS7	59.81[c]	67.32[c]	18.19	36.18[b]	5.40[c]	9.06	30.40[a]	60.52[b]	1.081	9.14	32.68[c]	11.60	10.51	51.02	15.52
CS10	62.91[b]	70.19[b]	18.34	38.94[a]	5.63[b]	8.97	29.16[b]	61.86[a]	1.080	9.14	32.84[b]	11.79	10.60	51.12	15.73
CCS	63.88[a]	72.66[a]	18.24	39.80[a]	5.84[a]	9.16	28.54[c]	62.29[a]	1.080	9.10	32.40[d]	11.87	10.29	50.73	15.59
Pooled SEM	0.18	0.36	0.06	0.14	0.02	0.03	0.08	0.09	<0.001	0.01	0.02	0.02	0.03	.03	0.11

[a–d]For each column, means with no common superscript differ significantly ($P \leq 0.05$).

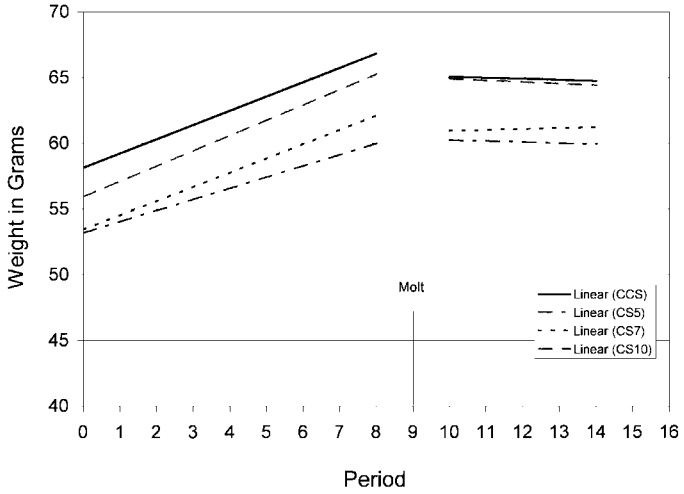

FIGURE 1. Egg Weight. CS5 = Control strain 5 from 1950 population, premolt $R^2 = 0.80$, postmolt $R^2 = 0.88$; CS7 = Control strain 7 from 1958 population, premolt $R^2 = 0.76$, postmolt $R^2 = 0.90$; CS10 = Control strain 10 from 1972 population, premolt $R^2 = 0.87$, postmolt $R^2 = 0.93$; CCS = Current control strain, H&N "Nick Chick" 1993, premolt $R^2 = 0.89$, postmolt $R^2 = 0.90$.

measurements. The overall low Haugh units seen in this study were possibly due to the 48-h time lapse between collection and testing. Generally, Haugh units are reported for eggs tested within 24 h of collection. Relative differences in Haugh units between the CCS and CS were similar to those reported by Jackson *et al.* (1986).

The relative percentage yolk in the CCS was significantly lower than in the CS although the total absolute amount of yolk was similar across all strains. This relationship is in agreement with the research of Akbar *et al.* (1983) and Jackson *et al.* (1986), who found that eggs from the CS5 and CS7 strains were smaller and contained a higher percentage yolk and lower percen-

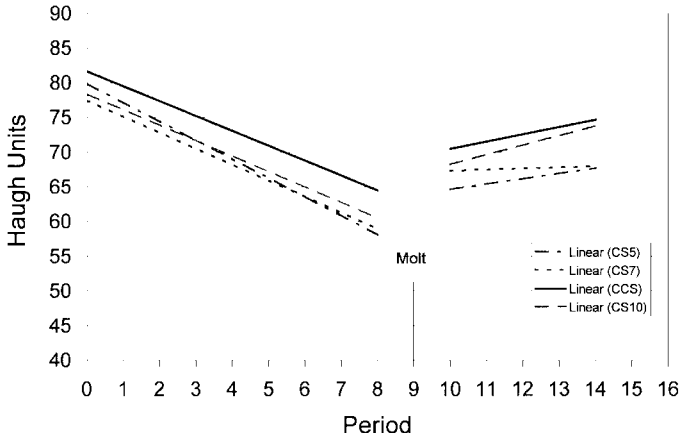

FIGURE 2. Haugh Units. CS5 = Control strain 5 from 1950 population, premolt $R^2 = 0.79$, postmolt $R^2 = 0.87$; CS7 = Control strain 7 from 1958 population, premolt $R^2 = 0.89$, postmolt $R^2 = 0.80$; CS10 = Control strain 10 from 1972 population, premolt $R^2 = 0.86$, postmolt $R^2 = 0.90$; CCS = Current control strain, H&N "Nick Chick" 1993, premolt $R^2 = 0.93$, postmolt $R^2 = 0.94$.

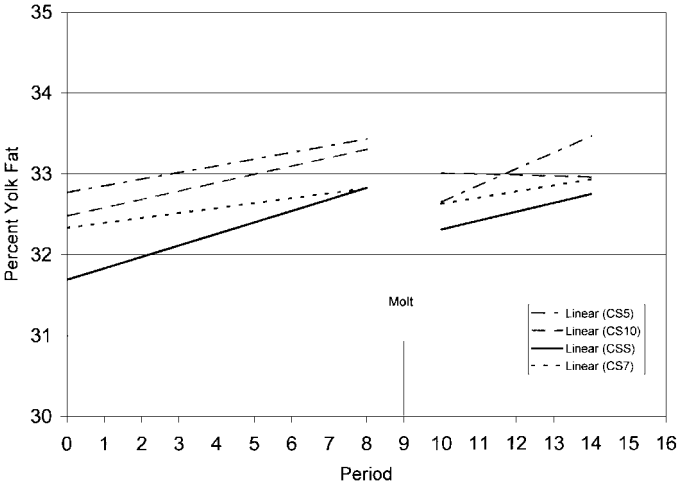

FIGURE 3. Percentage yolk fat. CS5 = Control strain 5 from 1950 population, premolt $R^2 = 0.98$, postmolt $R^2 = 0.99$; CS7 = Control strain 7 from 1958 population, premolt $R^2 = 0.89$, postmolt $R^2 = 0.91$; CS10 = Control strain 10 from 1972 population, premolt $R^2 = 0.97$, postmolt $R^2 = 0.94$; CCS = Current control strain, H&N "Nick Chick" 1993, premolt $R^2 = 0.94$, postmolt $R^2 = 0.89$.

tage albumen than a current commercial strain. In the study by Akbar *et al.* (1983), differences in egg composition of the control strains and selected strains were examined within one egg size category. Further analysis of our data after sorting by egg size was performed to directly assess whether the differences seen between the strains were attributable to only egg size rather than genetic group (data not shown). The same compositional differences were observed within the groups of similar-sized eggs, which would lead us to conclude that the differences we observed in egg composition are indeed an indication of genetic change.

Although previous researchers have reported strain differences with respect to albumen quality traits, no significant differences in albumen protein or albumen solids were found between the strains in this study. No significant difference in percentage yolk solids was found between strains. These observations agree with those of Akbar *et al.* (1983), who found no differences in yolk solids between selected and control strains.

Percentage yolk fat values obtained from the CCS were significantly lower ($P < 0.05$) than those obtained from the earlier strains (Figure 3). Further research will be needed to determine whether this lower percentage yolk fat is consistent over all current laying strains.

This study proposes that although there has been genetic selection for increased egg size over the past 40 yr, shell egg quality traits have improved or been maintained at a high level. Results suggest genetic selection has provided larger eggs containing smaller percentage yolk and potentially a lower percentage of yolk fat.

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