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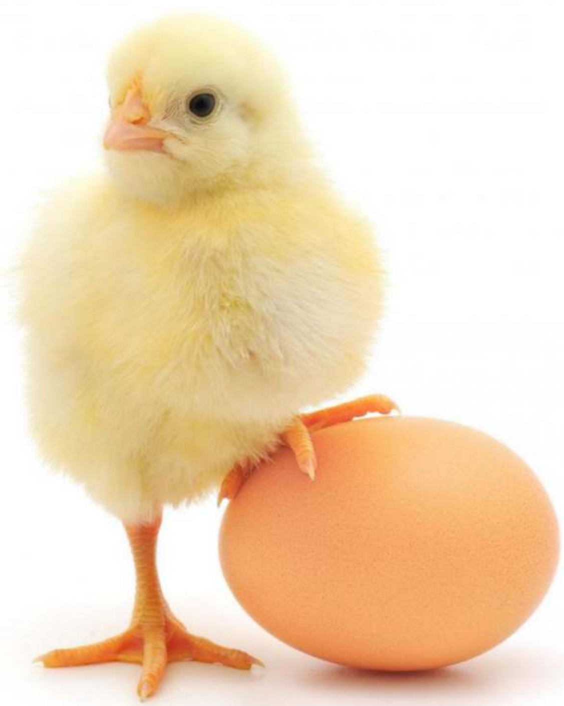

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Shell Characteristics of Eggs from Historic Strains of Single Comb White Leghorn Chickens and the Relationship of Egg Shape to Shell Strength

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Abstract: The effect of long term genetic selection on shell characteristics was determined by analyzing eggs acquired from Agriculture Canada: Ottawa Control Strain 5, from a 1950 base population; 7, from a 1959 population; and 10, from a 1972 population. H&N "Nick Chick" 1993 commercial strain was also included because it shares genetic ancestry with the three historic strains. Eggs were collected beginning at 28 wk of age, then every 4 wk through the end of the study at 86 wk of the laying cycle and egg weight, egg height, egg width, shell weight, shell thickness, egg specific gravity, and shell breaking force measured. The relationship of egg shape and weight as factors affecting shell strength were also investigated. Significant differences ($P < 0.05$) were found between strains for egg shape and a progressive increase in weight and surface area of eggs from the 1950 strain to the current strain. The shape index indicates that the current strain has increased egg size with the greatest increase seen in egg width. The mean breaking force of eggs from the current strain was higher ($P< 0.05$) than the other strain's eggs with no strain differences in percent shell weight, shell thickness, or specific gravity. A decline in breaking force, percent shell weight, and specific gravity was observed among all the strains over the production period. The results from this study suggest that genetic selection has produced larger eggs that are rounder in shape.

Key words: Genetic selection, shell strength, egg shape index

Introduction

Genetic differences in eggshell formation characteristics exist between species, and between breeds, strains and families within the species (Buss, 1982). He indicated that eggshell quality appears to be independent of rate of production and egg weight. Many researchers have reported an age effect on egg size and shell quality (Roland, 1976; Peterson, 1965). Eggs increase in weight over a production period while egg shell thickness and strength usually decreases.

Tyler and Geake (1953, 1958, 1961) have shown that a determination of shell weight per unit surface area is an exceedingly accurate assessment of shell thickness. In fact, they believe shell thickness is probably more reliable as an indication of the mean value of the whole eggshell than the direct measurement itself. The differences in specific gravity of fresh eggs are due almost entirely to differences in the amount of shell present (Wells, 1968), and it appears that egg specific gravity was the best measurement of shell strength. Tyler (1961) reviewed the literature regarding attempts to predict resistance of the eggshell to fracture on the basis of physical measurements. He indicated that shell strength and thickness were highly correlated, but that there is confounding by the number of pores, shell protein, membrane, and shell shape. The studies of Frank *et al.* (1964, 1965) indicated that the physical variables of shell weight, percent shell, shell thickness and specific gravity could not explain more than 60 percent of the variation in crushing strength. Richards and Staley (1967) reported that the inclusion of shape index had a significant effect on the proportion of crushing strength variation.

Little research has been done to examine the influence of selection on eggshell structure and shape in egg production stocks. Therefore, this study was designed to examine the influence of genetic selection on eggshell characteristics including thickness, shape, specific gravity and shell strength.

Materials and Methods

Eggs were obtained from three historical strains and one current strain of commercial Single Comb White Leghorn hens. The three random bred control strains are composite representatives of the genetic stocks that were in use by the commercial egg industry over the past five decades. Three of the Ottawa Control Strains were acquired from Agriculture Canada; Strains 5 (CS5), 7 (CS7), and 10 (CS10) were used as comparison against a current commercial laying stock (CCS). Fairfull *et al.* (1983) described the composition of the three random-bred, control strains.

Table 1: Effect of strain on egg weight, shell weight, shell thickness, percent shell, shell breaking force, egg height and width, shape index, specific gravity and surface area

Strain[1]	Egg Weight (g)	Shell Weight (g)	Shell Thickness (mm)	Percent shell %	Shell Breaking Force (g)	Egg Height mm	Egg Width mm	Shape Index	Specific Gravity	Surface Area (Cm^2)
CS5	58.57a	5.28a	0.46a	9.03a	3296a	59.29a	42.36a	71.54a	1.082a	70.25a
CS7	59.81b	5.40a	0.46a	9.06a	3232a	59.09a	42.78ab	72.48ab	1.081a	71.30b
CS10	62.91c	5.63b	0.46a	8.97a	3222a	59.31a	43.61b	73.59b	1.080a	73.87c
CCS	63.88d	5.84c	0.47a	9.16a	3367b	59.89b	44.70c	74.76c	1.080a	74.70c

abcd For each column, means followed by different letters are significantly different at ($P< 0.05$)
[1]CS5 = Ottawa Control Strain 5; CS7 = Ottawa Control Strain 7; CS10 = Ottawa Control Strain 10; CCS = Current Commercial Strain.

CS5 was formed from a common base population of laying hens in 1950. The CS7 was formed in 1959 from four Leghorn strains comprised of: H&N "Nick Chick", Hy-Line® 934A, Kimber K137, and Shaver 288. CS10 was formed in 1972 from four Leghorn strains: Babcock B300, H&N "Nick Chick", Hy-Line® 934, and Shaver 288. These strains were maintained in a random-bred, unselected manner since their formation. The current strain was the H&N "Nick Chick", chosen because it has been under continuous selection since the early 1950's and had common ancestry with the control strains. The use of the random bred controls allowed direct comparison using equivalent modern laboratory equipment and methods. Husbandry practices used throughout the experiment described by Jones *et al.* (2001) ensured that each of the strains were treated in the same manner. At eighteen weeks of age, all birds were moved to an environmentally controlled laying house containing four rows of tri-deck layer cages. Six hens were housed per cage with density and feeder space being 361 cm^2 and 10.2 cm, respectively. The strains were equally represented in all cage levels and rows to eliminate house environment variations and were maintained using a phase feeding program regulated based on flock performance and feed intake.

Egg sample collection commenced when the birds were 28 wk of age. Subsequent eggs from each strain were collected every 4 wk for the remainder of the first cycle and through the second cycle (86 wk). The experiment included eggs collected prior to the molt at 62 wk and post-molt.

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. A commercial probability plotting paper was used to determine the average specific gravity of each strain. After specific gravity measurements were taken, eggs were stored at 5 ^{0}C overnight and broken out the following day. A ten-egg sample from each of the four test strains was randomly selected and weighed. After breakout, the shells were rinsed and air-dried under a fume hood to constant weight and the shell weight recorded.

Shell thickness measurements of the dried shells with the membrane still intact were taken with a micrometer to the nearest 0.01 mm. The measurements were taken at two random locations about the equator of each shell. The surface area, expressed as centimeters squared (cm^2), of each egg was estimated using the formula of Carter (1975), $3.9782 \times W^{.7056}$, where W is the egg weight in grams.

A sample of fifty sound shelled eggs from each strain was selected, weighed, and height and diameter measurements taken. Shape index was calculated by the normal method of (diameter/height) x 100. Quasi-static compression tests were conducted on an Instron 1122 machine modified with a Syntech Renew electronic package. Data were collected and analyzed on a Pentium computer utilizing Syntech Testworks software (MTS, Minneapolis, MN.). Eggs were compressed between two flat plates with the major axis perpendicular to the compression surface. This orientation was chosen to most resemble crushing forces associated with packaging and shipping. The force applied to the egg during compression was recorded. The eggs were compressed at a rate of 5 mm/minute. Breaking force was defined as the force in grams required to fracture the shell. When the shell failed, the directional movement of the compression plate was reversed and the egg removed.

Statistical analysis: The data were analyzed using the General Linear Models procedure (SAS Institute, 1987). The means indicated as being significantly different were separated using the LS Means.

Results and Discussion

The mean values for the egg quality attributes measured over the fourteen-month period are shown in Table 1. Period means followed similar patterns.

A progressive increase in egg weight and surface area was seen between strains. This relationship is in agreement with the research of Akbar *et al.* (1983) and Jackson *et al.* (1986) which found that eggs from the 1950 and 1959 control strains were smaller than a current commercial stock. A significant ($P<0.05$)

production period effect was also observed with egg weights increasing over time within all strains, with a concurrent increase in surface area and weight of the shell. No significant differences in percent shell, shell thickness or specific gravity were seen between the strains. The mean breaking force for the current strain was significantly ($P < 0.05$) higher than for the other strains. Since this variation cannot be explained entirely by the shell quality measurements listed above, we investigated the correlation of egg shape to breaking force. The shape index indicates that the current strain of eggs have not only increased in size, but have become more round in shape. The importance of shape characteristics has been previously noted when predicting breaking force, Richards and Staley (1967) and Frank *et al.* (1964). Strain data were sorted by egg size and further analysis conducted to assess if the differences in shell strength seen between the strains were attributable to egg size and shape rather than genetic group. No significant correlation was found between breaking force and size or shape of eggs within a strain. This would lead us to conclude that the differences we obtained in shell strength are indeed an indication of genetic change.

A decline in breaking force was observed among all the strains over the production period with the current strain eggs declining at the fastest rate. This decline was also seen in percent shell weight and specific gravity. These declines combined with increased egg weight suggest a reason for the shell quality problems associated with older birds.

The results of this study suggest that egg shell thickness and strength has improved in the current commercial strain. Results suggest genetic selection has resulted in an egg shape change. The shell eggs are larger, and rounder with a higher resistance to crushing forces.

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