Quality and compositional characteristics of layer hens as affected by bird age

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Abstract

Improvements in the management, disease control, nutrition, and genetics of laying hens as well as advancements in processing technology over the last 40 years have undoubtedly changed egg quality and composition, yet few studies have documented this progress. To date no comprehensive study exists that looks at breaker eggs from current commercial stock over a complete laying cycle and what studies that have been conducted look at only a few of the egg characteristics. In order to study such problems strains of layer hens bred for the egg breaking industry were evaluated looking at the quality, functional, and biochemical characteristics of eggs over a complete two year cycle which includes a moult. However, only egg quality and the first year of that cycle will be discussed in this presentation.

The strains that were utilized are Hy-Line W-36, Hy-Line W-98, Hy-Line CV-20, ISA White, and Bovans White. These strains were selected based upon their egg weight, availability, and market share. The eggs from these strains were collected monthly from the 35th North Carolina Layer Performance and Management Test in which performance of the strains was monitored under identical rearing and environmental conditions throughout the test. The hens were provided nutrients to meet the needs of all the hens based upon compilation of the breeder recommendations. Once collected the quality and compositional properties of the eggs such as vitelline membrane strength; percentage of shell, yolk, and albumen as based upon their component parts; and Haugh units (HU) were evaluated.

While vitelline membrane strength (2.33 to 1.92 gms), percentage of shell as a component part (10.33 to 7.83%), and Haugh units (89.63 to 68.76 HU) decreased slightly over time, bird age did have a significant effect on all three. The percentage of albumen and yolk was significantly impacted by bird age. These component parts also followed previously reported data that showed an inverse relationship between the two, where as the percentage of albumen (70.01 to 62.57 %) decreased as the bird aged the percentage of yolk (28.43 to 19.67 %) increased. By comparing and characterizing all egg components this should give the breaking industry desperately needed information that is not available on modern layer strains.

Introduction

Commercial strains of egg production layers have been selected primarily for high production of eggs with acceptable market weights whereas little, if any, emphasis has been directed towards egg composition. Additionally, improvements in the management, disease control, nutrition, and genetics of layers as well as advancements in processing technology over the last 40 years have undoubtedly changed egg quality and composition, yet few studies have documented this progress. There have been some studies (Cook and Briggs, 1977; Marion et. al., 1964; Jackson *et al*., 1986) which looked at breed, strain and age and their impact on egg composition. The general conclusion was the proportion of yolk tended to be greater and the proportion of albumen smaller in small eggs than in larger eggs. Other studies (Rodda *et al.*, 1977.; May and Stadelman, 1960; Rose *et al.*, 1966; Akbar *et al.*, 1983; Hill *et al.*, 1966) have reported that selected commercial strains weighed more and contained higher percentages of albumen, albumen solids and albumen protein. However, this variation among strains has often been related to variation in egg size. In the older literature, more variability was seen in the component parts of eggs from younger hens than eggs from older hens. In general, there was a smaller percentage of yolk (Asmundson, 1933; Olsson, 1936) and a larger percentage of albumen (Olsson, 1936) in eggs from younger birds than in eggs from older birds (see table below).

Bird Age	% Yolk	% Albumen	% Shell
Younger Hens			
Asmundson (1933)	27.4	61.6	11.1
Olsson (1936)	28.0	61.1	10.9
Older Hens			
Olsson (1936)	29.8	59.6	10.6

Romanoff and Romanoff (1949) reported that during the first few months of lay, the relative amount of yolk in the egg gradually increases, whereas that of the shell decreased rapidly and the percentage of albumen remained the same.

Bird age has also been reported to have an effect on egg size and composition traits. Most of these trends can be reversed by forced moulting, but resumes afterwards. Eggs 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 of albumen increases progressively while the percentage of yolk 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 generally reported that as hens age the yolk quality traits generally improve, whereas the albumen traits worsen. However, Tharrington *et al.* (1999) reported no significant differences in between strains for albumen protein, solids, pH or yolk solids in eggs with significantly different weights. In fact, they reported genetic selection had produced larger eggs containing lower percentage of yolk while overall egg quality had been maintained or improved.

The yolk is enclosed in a thin, pliable envelop, known as the vitelline membrane. The vitelline membrane breaks down as the egg ages. In addition, it is the vitelline membrane strength which allows the yolk to remain intact during the breaking operation. Therefore, the stronger the vitelline membrane the less likely it is to rupture during the breakout process.

One of the most widely used measurements for albumen quality is the Haugh unit. The Haugh unit is an expression relating egg weight and height of thick albumen--the higher the Haugh unit the better the egg quality.

Materials and methods

The strains that were utilized in this study are: Hy-Line W-36, Hy-Line W-98, Hy-Line CV-20, ISA White, and Bovans White from the North Carolina Layer Management and Performance Test by Anderson (2004). These strains were selected based upon their egg weight, availability, and market share. The breaker market is looking for strains that will produce layer eggs. This would increase the throughput for any given breaking machine. The eggs from the selected strains have these characteristics. In addition, some of these strains hold a significant market share of the current production flocks.

Three flats of eggs were collected from the five different strains of breaker eggs. Samples were collected starting in May 2003 and subsequent samples were collected every month for a 12-month period. Upon arrival the eggs were further divided into two separate flats. One flat per strain was used to conduct tests related to albumen and yolk quality and composition, while the other flat was used to conduct similar test on whole eggs.

Eighteen eggs were randomly selected from one flat from each of the five strains. Haugh unit values (Haugh, 1937) were collected using the Egg Multi Tester by Robotmation. Whole egg weight, albumen height, yolk colour, and egg grade measurements were also collected simultaneously with the Egg Multi Tester. After the Haugh measurements were obtained and the egg was broken out, weight data was gathered to calculate percentage of yolk as a component. Shells obtained from the Haugh unit measurements were rinsed and air-dried for 2 days and then weighed. Approximate albumen weight was then calculated.

Twenty-one eggs were randomly selected from the second flats from the five strains and vitelline membrane strength or compression measurements were taken using a Texture Technologies TA-XT2i Texture Analyzer (Tharrington *et al.*, 1998).

Results and discussion

Egg processors who break eggs to create a variety of egg products, want large eggs that consistently produce high quality egg products. The consistency is the major problem with eggs. It is well known that as the hen ages a number of changes occur in the egg. As stated earlier, bird age has been reported to have an impact on egg size and composition.

Egg weights generally increase as the bird ages. This is consistent with the results shown in Table 1. However, once the hens in this study reached the sixth period of production egg size became more consistent. Once egg weights plateaued to a consistent weight, do the contents remain the same? If so, the processor could blend eggs from younger and older flock for the desired component part. Unfortunately, it does not appear to be that simple.

Table 1 Egg composition.

Period	Egg Weight (grams)	Percent Shell	Percent Yolk	Percent Albumen
1	44.5^{h}	10.3	19.7^{g}	70.0^{a}
2	51.2^{g}	9.6	23.0^{f}	67.3^{b}
3	53.9^{f}	9.4	24.0^{e}	66.5^{c}
4	56.1^{e}	7.8	25.9^{d}	66.3^{c}
5	59.1^{d}	9.3	25.8^{d}	64.9^{d}
6	61.4^{c}	9.4	25.9^{d}	64.7^{d,e}
7	61.4^{c}	9.3	26.5^{c}	64.2^{e,f}
8	62.6^{b}	9.0	27.8^{b}	63.1^{g,h}
9	62.8^{a,b}	9.1	26.9^{c}	64.0^{f}
10	63.8^{a}	9.1	27.7^{b}	63.2^{g}
11	63.6^{a,b}	9.1	28.0^{a,b}	62.9^{g,h}
12	64.0^{a}	9.0	28.4^{a}	62.6^{h}

^{a,b,c,d,e,f,g,h} Period means within a column, followed by different letters, differ significantly (P<.05)

The general conclusion from previous research reported earlier in this paper was that the proportion of yolk tended to be greater and the proportion of albumen smaller in smaller eggs than in larger eggs. However as can be seen in Figure 1, albumen percentage decreases about ten percent over time and yolk increased. In 1977, Stadelman reported a standard range for percent albumen of 56 to 61 percent. This study found the range for albumen to be considerably higher 62 to 70 percent. Egg weight may account for a small part of the difference, but strain may play a bigger role than egg weight relative to the breakdown of component parts of the egg.

Haugh unit is an expression relating egg weight and the height of the thick albumen. It is generally accepted that the higher the Haugh unit value, the better the quality of the egg. It is also important that all eggs being evaluated at the same internal temperature. Age of the hen and season of the year can also impact Haugh unit values. This hen age impact can be seen in Figure 2 where Haugh unit values decreased from 89.6 to 68.8 over the twelve production periods

Figure 1. Component Parts

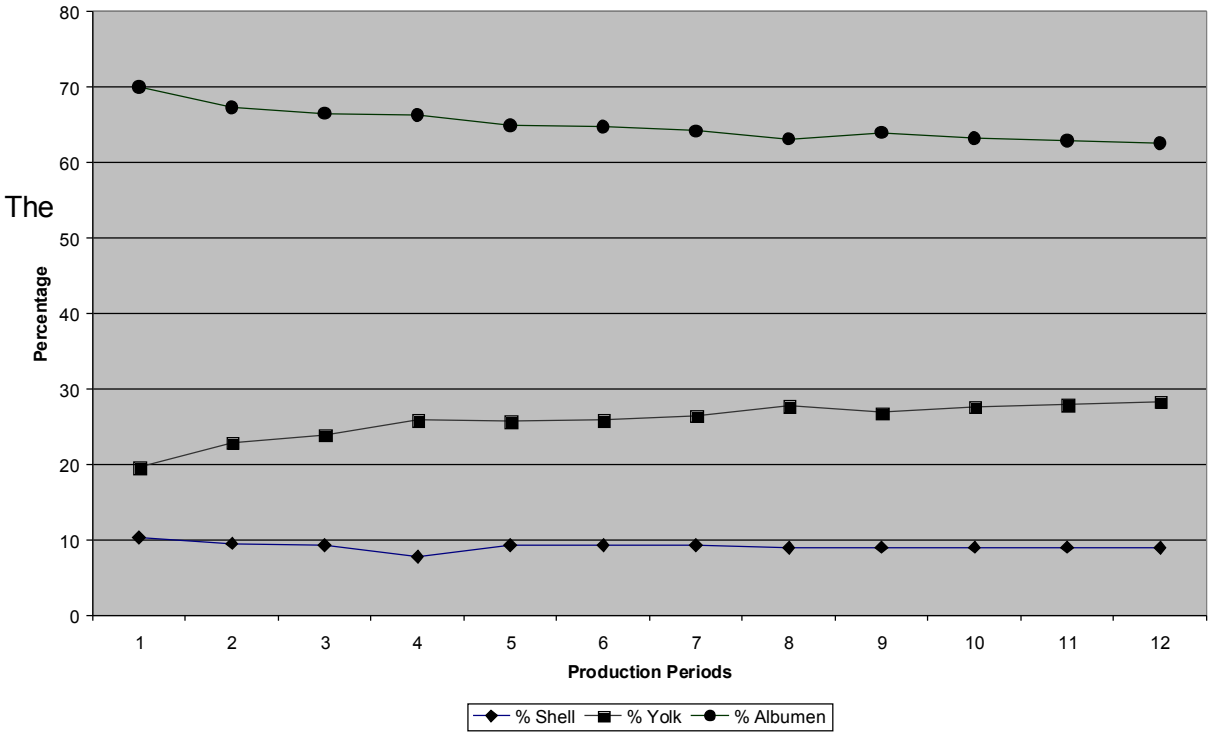

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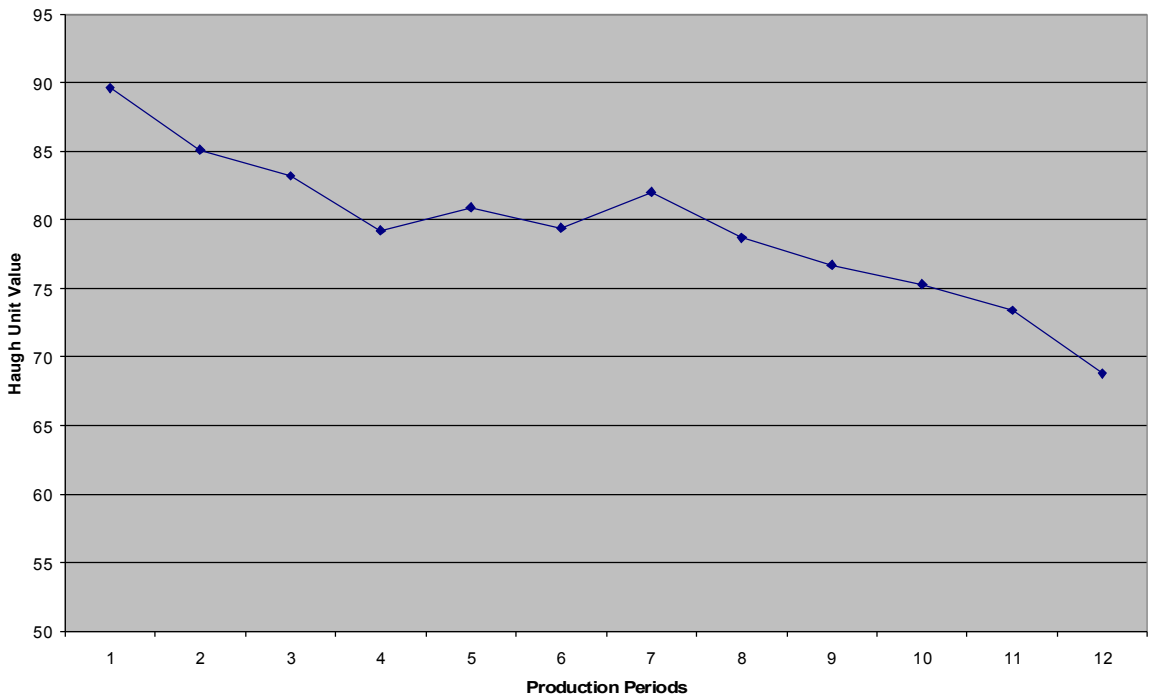
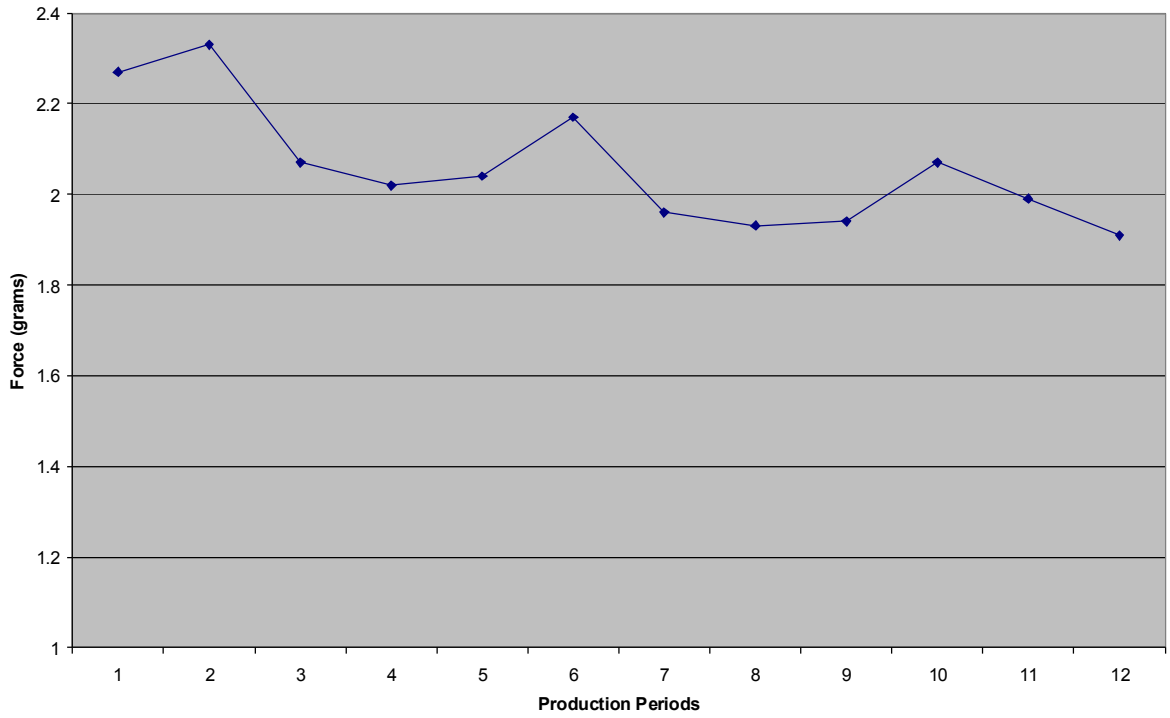
Figure 2. Haugh Units



The vitelline membrane strength decreased over time (2.27 g to 1.91 g). There are numerous factors (hen age, egg age, season, etc.) that can impact the membrane strength. Figure 3 shows how the vitelline membrane strength changed over the first year of production. This variation in strength could be contributing to the inconsistency seen in functionality of egg products. More information about the functionality characteristics of these eggs can be found in a companion paper entitled "Impact of Bird Age on the Functionality of Eggs from Current Layer Strains."

Figure 3. Vitelline Membrane Strength



In summary, while vitelline membrane strength (2.33 to 1.92 gms), percentage of shell as a component part (10.33 to 7.83%), and Haugh units (89.63 to 68.76 HU) decreased slightly over time, bird age did have a significant effect on all three. The percentage of albumen and yolk was significantly impacted by bird age. These component parts also followed previously reported data that showed an inverse relationship between the two, where as the percentage of albumen (70.01 to 62.57 %) decreased as the bird aged the percentage of yolk (28.43 to 19.67 %) increased. By comparing and characterizing all egg components this should give the breaking industry desperately needed information that is not available on modern layer strains

References

ANDERSON, K.E. (2004) First cycle report of the thirty fifth North Carolina Layer Performance and Management Test. North Carolina Cooperative Extension Service, North Carolina State University, Raleigh, NC. Vol. 35, No. 3, July 30, 2004.

AKBAR, M.K., J.S. GAVORA, G.W. FRIARS, and R.S. GROWE (1983) Composition of eggs by commercial size categories: Effects of genetic group, age, and diet. Poultry Science 62:925-933.

ASMUNDSON, V.S. (1933) Proceedings World's Poultry Congress (Rome), 5(2):344-348.

COOK, F. and G.M. BRIGGS (1977) Nutritive values of eggs. Pages 92-108 in: Egg Science and Technology. W.J. Stadelman and O.J. Cotterill, et. AVI Publishing Co., Westport, CT.

CUNNINGHAM, F.E., O.J. COTTERILL, and E.M. FUNK (1960) The effect of season and age on bird, egg size, quality and yield. Poultry Science 9:289-299.

HAUGH, R.R. (1937) The Haugh Unit for measuring egg quality. U.S. Egg & Poultry Magazine 43:552-555, 572-573.

HILL, A.T., W.F. KRUEGER, and HILL, A.T., W.F. KRUEGER, AN J.S. QUISENBERRY (1966) A biometrical evaluation of component parts of eggs and their relationship to other economically important traits in a strain of White Leghorns. Poultry Science 45:1162-1185.

IZAT, A.L. (1983) The effects of age and season on selected quality characteristics of shell eggs from several strains of commercial layer hens. M.S. Thesis, Texas A&M University, College Station, TX.

JACKSON, M.E., G.W. FRIARS, J.S. GAVORA, C.Y. LIN, R.S. GROWE, I. MCMILLIAN, and E. MORAN (1986) Comparison of control and selected strains, strain crosses, and commercial stocks of Leghorns for egg production efficiency. Poultry Science 65:16-25.

MARION, W.W., A.W. NORDSKOG, H.S. TOLMAN, and R.H. FORSYTHE (1964) Egg composition as influenced by breeding, egg size, age and season. Poultry Science 43:255-264.

MAY, K.N. and W.J. STADELMAN (1960) Some factors affecting components of eggs from adult hens. Poultry Science 38:1226.

OLSSON, N (1936) Proceedings World's Poultry Congress (Leipzig) 6(1):310-320.

RODDA, D.D., G.W. FRIARS, J.S. GAVORA, and E.S. MERRITT (1977) Genetic parameter estimates and strain comparisons of egg compositional traits. Br. Sci.18:459-473.

ROMANOFF, A.L and A.J. ROMANOFF (1949) Structure. Pages 117-118 in The Avian Egg, John Wiley & Sons, Inc., New York, NY,

ROSE, D.N., T. GRIDGEMAN, and D.A. FLETCHER (1966) Solids content of eggs. Poultry Science 45:221-226.

STADELMAN, W.J. (1977) Quality identification of shell eggs. Pages 29-40 in Egg Science and Technology, W.J. Stadelman and O.J. Cotterill, ed. AVI Publishing Company, Westport, CT.

THARRINGTON, J.B., P.A. CURTIS, K.E. ANDERSON, and F.T. JONES (1998) Measurement of the strength of the vitelline membrane of cryogenically cooled processed shell eggs. Poultry Science 77(Supp. 1):64.

THARRINGTON, J.B., P.A. CURTIS, F.T. JONES, and K.E. ANDERSON (1999) Comparison of physical quality and composition of eggs from historic strains of single comb white leghorn chickens. Poultry Science 78:591-594.