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Some Physical and Chemical Properties of Eggs from Hens of Five Different Stocks[1]

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INTRODUCTION

RESEARCH reports dealing with the influence of breed or strain of laying hens on the amount and composition of various egg components have appeared frequently in the literature in the past decade. Hens from different stocks have been shown to produce eggs differing in moisture and protein (Cotterill and Winter, 1954; May and Stadelman, 1960). It has also been reported that hens from different breeds or strains produced eggs differing in total lipids and fatty acid composition (Edwards *et al.*, 1960; Edwards, 1964). There is a possibility that part of these differences which have been attri-

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buted to genetic influence may have been only a reflection of egg weight since it has been shown that part of the variation in level of egg components between different stocks is only a reflection of change in egg size (Scott and Warren, 1941; Marion *et al.*, 1964).

This report is concerned with observations that have been made on the influence of 5 different stocks of laying hens on (1) physical characteristics of eggs such as total weight, component weights, and interior quality, and (2) the level and fatty acid composition of neutral lipids and phospholipids in whole eggs.

PROCEDURE

Eggs were sampled from hens of 5 different stocks and designated as follows: Athens Randombred—line 1; Canadian Randombred—line 2; Athens-Canadian Randombred—line 3; two commercial strains of White Leghorns—lines 4 and 5. The birds were housed in individual laying cages at the southern Regional Poultry Genetics Laboratory, Athens, Ga. They were fed the same feed and subjected to the same management practices.

Fifteen to 25 eggs were collected from each line on each of 4 successive days when the hens were in their third month of production. The eggs were held at 13°C. (70 to 80% relative humidity) for 7 days, after which they were weighed and broken out. Then, the thick albumen height of each egg was measured with a micrometer, and Haugh units were calculated by the method of Kilpatrick *et al.* (1960). Visual lightness (L), redness (a), and yellowness (b) values were read on a Hunter color meter after centering the yolk of the egg over the light aperture of the meter. A standard color plate having nearly the same L, a and b readings as that of egg yolk was used to calibrate the instrument.

Yolks were separated from albumen by passing the yolk back and forth between two 50 ml. beakers until all visible albumen was removed. The yolks were then weighed. Egg shells were carefully washed in tap water, dried at 105°C. overnight and weighed. The difference between egg weight and the weight of yolk and dry shell was calculated as albumen weight. The yolk and albumen from each egg produced on the first collection date were combined, homogenized, and held frozen for laboratory analysis. Yolks and albumen of eggs from the other 3 days of production were separately frozen and held for functional property tests which are not reported here.

Aliquots of eggs homogenized for laboratory analysis were placed in tared bottles, re-weighed, freeze-dried, and weighed again. Weight loss during drying was used to calculate moisture content of the eggs. Samples of dried eggs were weighed, homogenized in an Omni-mixer with chloroform (ratio of one gm. egg to 25 ml. chloroform), and filtered with suction into a tared flask. The lipids were recovered by evaporating the chloroform in a 70°C. water bath under a nitrogen stream. The flask containing the lipids was re-weighed and the weight difference used to calculate percent lipid in the egg. Chloroform was added back to the flask at the rate of approximately one ml. per 75 to 100 mg. of lipids. One ml. of this solution was spotted by pipette in a row along a 20×20 cm. thin layer plate previously coated with a layer of silica gel G 250 μ. in thickness. The chloroform quickly evaporated from the spots after which the plates were developed in tanks containing 100% chloroform. Separation of the lipids into neutral lipids, cholesterol, and phospholipids was clear cut and was found to be superior to similar methods utilizing petroleum ether, diethyl ether, and acetic acid (e.g. Privett *et al.*, 1962) for the

TABLE 1.—*Production, weight, components and quality of eggs from different lines of hens*

Lines	1	2	3	4	5
Production—%	65.8	62.4	63.9	66.2	66.2
Egg wt.—gms.[1]	56.0[a]	53.7[ab]	53.3[b]	52.5[b]	51.7[b]
Haugh unit	68.9	66.9	66.9	68.4	71.4
Yolk color—a/b	0.040	0.033	0.042	0.020	0.008
Yolk color—L	60.9[a]	61.8[ab]	61.7[ab]	62.8[b]	62.3[b]
Shell—%	9.13[a]	9.46[ab]	9.24[a]	10.02[b]	9.87[b]
Yolk—%	30.71[ab]	31.32[a]	30.86[ab]	29.24[c]	29.56[bc]
Albumen—%	60.16	59.22	59.90	60.74	60.57

[1] Values having the same superscript letter are not significantly different ($P<0.05$).

separation of the relatively large quantity of lipids applied. The method of Privett *et al.* (1962) was used to locate, identify, and recover the lipid components after which the neutral lipid and phospholipid fractions were methylated and analyzed for fatty acids by procedures previously reported (Marion and Woodroof, 1963).

RESULTS AND DISCUSSION

Since the rate of egg production could possibly influence the level and composition of egg components, production for the 28-day period immediately preceding the days during which eggs were collected was recorded and is presented in Table 1. Egg production level for this period was not significantly influenced by lines. Mean egg weights, Haugh units, yolk color readings, and percentage of egg components (shell, yolk, and albumen) are also presented in Table 1.

Egg weights were found to be significantly affected by lines ($P<0.05$). Hens from line 1 produced heavier eggs than those in lines 3, 4, and 5, while line 2 eggs were intermediate in weight. Since egg size is a highly heritable trait, differences such as these might be expected among genetically different lines. In the present study, egg weights were obtained so that the influence of different lines on egg composition could be delineated from the influence of egg size.

In the lines examined, Haugh unit values did not differ significantly although this measure has been shown to be under genetic influence (May *et al.*, 1957), and is amendable by selection.

Yolk color readings are presented as L values, and a/b values in Table 1. L values were fairly consistent within lines and were significantly lower in line 1 than in lines 4 and 5. Lines 2 and 3 were intermediate. Although mean values for a/b varied markedly between lines, the differences were not statistically significant due to considerable variation within the lines. The differences observed between lines in L values are in agreement with results presented by Farnsworth and Nordskog (1955) who found line differences in yolk color in some years. However, these authors demonstrated a large year or seasonal effect on yolk color and estimated the heritability of this trait to be only .15. This indicates that genetic changes in yolk color would be made slowly.

Egg components (shell, yolk, and albumen) differed with lines. Percent shell tended to be inversely proportional to egg weight. This is logical since shell weight is a function of surface area (Mueller and Scott, 1940). Also, Cotterill *et al.* (1962) reported that 20 oz./doz. eggs had 0.75% more shell than 30 oz./doz. eggs. In the present study, a comparison of the mean egg weights and percent shell indicates that the percent shell differences noted between lines were much greater than those expected to be caused by egg size influence alone.This suggests that lines *per se* had a marked influence on percent shell.

Mean percent yolk values, when calculated as a percentage of whole egg, or as a percentage of egg contents, were significantly influenced by lines. Within lines there appeared to be a negative association between percent yolk and egg weight (correlation values of −0.494, −0.469, −0.322, −0.073 and −0.002 for lines 1 to 5, respectively), which agrees with the observations that an increase in egg size results in a decrease in percent yolk and an increase in percent albumen (Scheinberg *et al.*, 1953; Marion *et al.*, 1964). However, the percent yolk means for each line do not vary negatively with egg size means. In fact, a positive correlation (0.435) between percent yolk and egg weight means was noted, thus furnishing evidence that percent yolk is under genetic control and not mediated by egg size alone.

Levels of moisture, total lipids, neutral lipids, and phospholipids found in eggs from hens of different lines are reported in Table 2. Percent moisture was significantly influenced by lines, being lowest for line 2 and highest for line 5 with other lines intermediate. These moisture values are probably a reflection of percent yolk in the egg since these two factors appear to be negatively correlated and egg yolk contains a much lower level of moisture than egg albumen.

Total egg lipids, when calculated as a percentage of egg contents, egg dry matter, or wet yolk, were found to be significantly higher for lines 1, 2, and 3 than lines 4 and 5. The data in Table 2 support previous reports (Edwards *et al.*, 1960; Edwards, 1964) showing that egg lipids may differ with strain of hens. The present data further demonstrate that differences in total egg lipids between lines are not simply effects of differences in egg yolk size, but reflect variations in the ratio of lipid to other chemical components in the yolk itself. Therefore, selective breeding for lipid characteristics of eggs should be done on the basis of lipid determinations, and not by determining proportions of egg components alone. When the difference between weight of total egg contents and weight of moisture plus lipid in egg contents was calculated as fat-free egg solids and analyzed, lines 4 and 5 had significantly higher values. This was possibly due to a difference in protein level since Arroyave *et al.* (1957) and May and Stadelman (1960) have shown that hens from different stocks may produce eggs differing in protein content.

When total lipids were separated into neutral lipids and phospholipids, no difference between lines was noted if the two lipid fractions were expressed as a percent of total lipids. Since total lipids in

TABLE 2.—*Chemical composition of eggs from different lines of hens*

Lines	1	2	3	4	5
Moisture—% of egg contents[1]	74.12^{ab}	73.81^{a}	74.23^{ab}	74.48^{bc}	75.03^{bc}
Lipids—% of egg contents	11.99^{a}	12.24^{a}	11.92^{a}	10.53^{b}	10.53^{b}
Lipids—% of egg solids	46.35^{a}	46.69^{a}	46.18^{a}	41.34^{b}	42.07^{b}
Lipids—% of wet yolk	35.53^{a}	35.53^{a}	35.23^{a}	32.67^{b}	31.95^{b}
Fat-free egg solids—%	13.89^{a}	13.95^{a}	13.85^{a}	14.99^{b}	14.44^{b}
Neutral lipids—% of lipids	85.05	85.72	84.80	85.87	85.18
Phospholipids—% of lipids	14.95	14.28	15.20	14.13	14.82
Neutral lipids—% of egg contents	10.20^{a}	10.49^{a}	10.11^{a}	9.05^{b}	8.97^{b}
Phospholipids—% of egg contents	1.79^{a}	1.75^{a}	1.81^{a}	1.48^{b}	1.56^{b}

[1] Values having the same superscript letters are not significantly different ($P<0.05$).

the egg were lower for lines 4 and 5, values for the two lipid fractions were lower also when expressed as a percent of egg contents. The finding that the ratio of these two fractions did not vary between breeding lines does not preclude the possibility of difference existing between stocks other than those examined here.

The fatty acid composition of the neutral lipid and phospholipid fractions of eggs is shown in Tables 3 and 4. Of the 10 fatty acids detected in neutral lipids only 4 were significantly influenced by lines (16:1, 18:0, 18:1, and 18:2). Generally higher values for 16:1, 18:0, and 18:1, and lower values for 18:2 were noted for lines 4 and 5 than for the other lines. Since egg lipids are predominantly neutral lipids, these data agree with those published by Edwards (1964) in which it was shown that total lipids of eggs from different breeds or strains differed in fatty acid content.

TABLE 3.—*Fatty acids of egg neutral lipids from different lines of hens*

Lines	1	2	3	4	5
Fatty acid[1]	%	%	%	%	%
14:0	0.6	0.5	0.6	0.6	0.5
14:1	0.2	0.3	0.4	0.2	0.2
16:0	26.1	26.0	25.8	24.8	23.9
16:1	5.0	4.9	5.7	4.7	4.4
18:0	5.9	6.6	6.1	7.3	8.0
18:1	47.4	45.4	46.9	49.9	50.1
18:2	12.7	13.6	12.1	10.9	11.3
18:3	0.7	0.8	0.7	0.7	0.7
20:4	0.3	0.4	0.2	0.2	0.3
24:1	1.0	1.6	1.5	0.7	0.5
Grouping of significant means:[2]					
16:1	5.7	5.0	4.9	4.7	4.4
18:0	8.0	7.3	6.6	6.1	5.9
18:1	50.1	49.9	47.7	46.9	45.4
18:2	13.6	12.7	12.1	11.3	10.9

[1] Carbon chain length: number of double bonds.
[2] Values underscored by the same line are not significantly different ($P<0.05$).

TABLE 4.—*Fatty acids of egg phospholipids from different lines of hens*

Lines	1	2	3	4	5
Fatty acid[1]	%	%	%	%	%
14:0	0.3	0.3	0.3	0.3	0.3
14:1	0.2	0.1	0.1	0.1	0.1
16:0	26.5	26.9	25.5	25.2	26.0
16:1	2.0	1.8	1.9	1.8	1.6
18:0	17.3	17.4	16.9	16.2	17.8
18:1	26.1	25.6	26.5	28.3	26.9
18:2	12.8	12.6	12.5	12.3	12.2
18:3	0.4	0.4	0.3	0.4	0.3
20:4	7.7	7.6	7.6	8.0	8.4
22:0	0.5	0.5	0.5	0.6	0.5
22:6	2.4	2.4	2.4	3.0	2.8
24:1	1.2	1.4	1.6	1.2	0.8
24:2	2.9	3.2	3.4	2.5	2.2
Grouping of significant means:[2]					
22:6	3.0	2.8	2.4	2.4	2.4

[1] Carbon chain length: number of double bonds.
[2] Values underscored by the same line are not significantly different ($P<0.05$).

In contrast to neutral lipids, the phospholipid fraction contained 13 fatty acids of which only one, 22:6, was significantly influenced by lines. This is an indication that egg lipids are similar to chicken tissue lipids in that neutral lipids are much more subject to change in fatty acid composition than phospholipid (Marion, 1964). These fractions also resemble those of tissues by having higher levels of 18:0 and very long chain polyunsaturated fatty acids in phospholipids than neutral lipids. The higher levels of these particular fatty acids in phospholipids are accompanied by decreased levels of 16:1 and 18:1.

The levels of 18:2 and 20:4 were not positively related in neutral lipid and phospholipid fractions either between or within lines as has been reported for certain chicken tissues. In fact, the reverse phenomenon has been noted in egg lipids by Edwards (1964) and appears to be supported by this study. Lines 4 and 5 produced eggs with lower levels of 18:2 in neutral lipids than lines 1, 2 and 3. The lower levels of 18:2 in neutral lipids of lines 4 and 5 were accompanied by slightly higher levels of 20:4 and 22:6 in the phospholipid fraction.

SUMMARY

Eggs from 5 different stocks of hens differed significantly in weight, percent shell, percent yolk, visual lightness (L) of yolks, moisture content, lipid content, and content of some fatty acids. Haugh units and proportion of neutral lipids to phospholipids were not significantly influenced by the stocks examined.

From this study the following conclusions were made:

(1) The proportion of egg shell and egg yolk to total egg weight was influenced by breeding as well as being controlled by egg size.

(2) The moisture level of eggs was negatively associated with percent of yolk.

(3) Changes in percent yolk did not account for changes in total egg lipid, demonstrating that the level of chemical components in the yolk itself may possibly be amendable to selection.

(4) Changes in fatty acid composition among different stocks were primarily a reflection of changes in neutral lipid fatty acids, since phospholipid fatty acids tended to be more constant.

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