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Effects of Age and Storage Duration on Relationships among Albumen Quality Traits and Egg Weight in Japanese Quails

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Abstract: A total of 154 Japanese quail eggs which were stored throughout 0, 1, 4 and 7 days at 18°C and 60% RH from 10, 15 and 20 weeks of age were used to investigate relationships among different measures of thick albumen quality and Egg Weight (EW). Eggs were weighed and broken onto a glass surface and Albumen Height (AH), albumen pH, logarithm of AH, Haugh Unit (HU) and Internal Quality Unit (IQU) were determined. It was also determined that the correlation coefficients and linear regressions among the examined measurements. Both the decreases in AH, log of AH, HU and IQU or the increase in pH denote any deterioration in thick albumen characteristics by the age of hen and/or the storage duration. The regression coefficient of the albumen pH on age of the quail hen was merely found to be insignificant and rest of the albumen quality parameters were negatively affected by the hen age increased with low R^2 values. On the other hand, all of the regression coefficients of the albumen quality parameters on storage duration were found to be significant. While the albumen pH increased by increasing storage duration, rest of the other quality parameters were decreased by the prolonged storage. The R^2 values for storage duration were found to be relatively higher and more respectable than for hen age. There is no significant and/or fixed association among the examined measurements. Thus, it is not possible to develop any generalized (i.e., valid in all cases) formula which assumed any fixed association such in HU or IQU. In conclusion, albumen quality variables must be used without any adjustment especially for the appropriate comparisons among diverse groups of eggs.

Key words: Albumen quality, albumen height, albumen pH, quail, egg weight, Turkey

INTRODUCTION

Albumen quality is a standard measure of egg quality that is most often measured as the height of the thick albumen or a function of this such as the Haugh Unit (HU). The determinants of AH are not completely understood (Williams, 1992) although, the components of the albumen and their chemical and functional characteristics have been described (Robinson, 1987; Li-Chan and Nakai, 1989). The content and nature of ovomucin appear to be primarily responsible for determining AH but the chemical changes in storage that cause the reduction in AH are less clear. Reduced AH has been variously attributed to proteolysis of ovomucin, cleavage of disulfide bonds, interactions with lysozyme and changes in the interaction between α and β ovomucins with no clear favourite (Stevens, 1996). But there is no practical method to determine these involved biochemical occurrences. The unit proposed by Haugh (1937) implies a positive regression of 0.05 mm Albumen Height (AH) per g of chicken egg weight (Eisen *et al.*, 1962). That is to say, the HU adjusts the thick albumen height according to the Weight of the Egg (EW) and it uses a log scale because AH declines with storage in a logarithmic fashion (Silversides and Budgell, 2004). The HU has been used extensively (Williams, 1992) although, many researchers (Eisen *et al.*, 1962; Nestor and Jaap, 1963; Kidwell *et al.*, 1964; Silversides and Villeneuve, 1994) have criticized it and have shown that the adjustment for EW implied by the HU is incorrect, except possibly in the sample of eggs measured by Haugh (1937). Silversides and Villeneuve (1994) proposed simply measuring the height of the thick albumen without a correction for EW.

On the other hand, another formula which is called Internal Quality Unit (IQU) was developed to measure internal quality of the Japanese quail eggs by Kondaiah *et al.* (1983). While they were comparing the functions (Linear, quadratic and power regression functions) on the basis of R^2 value the coefficient of determination and the minimum standard error of estimate the best predicted function was determined. Conclusively, they suggested that the power function ($Y = ax^b$) fitted well because of the standard error was small (0.167) compared with both the linear or quadratic functions (0.689) in all data sets and in pooled data. In the IQU formula when the EW is 10 g, the expression ($4.18-0.8989W^{0.6674}$) is nearly zero and thus the adjusted

AH is the same as that of observed AH. While the EW was significantly associated with the AH, the correlation coefficient was found to be insignificant (-0.13) among the EW and the IQU. Thus, Kondaiah *et al.* (1983) were concluded that the IQU formula adjusts the influence of EW on AH. They have also reported that the IQU has got the disadvantage of either over-estimating or under-estimating the egg quality when the mean EW deviated much on either side of 10 g in a particular data. In other words, IQU for quail eggs has got a limitation as a measure of internal quality for the eggs which are smaller or larger than 9-11 g (Kondaiah *et al.*, 1983). In early literature, it was reported that this disadvantage also existed for HU when the EW deviated much on either side of 56.5 g (Eisen *et al.*, 1962).

In this study, it was aimed that to investigate possible associations between EW and thick albumen quality variables and to inspect validity of the fixed relations which were previously suggested for eggs from chicken or quail hens. For this purpose, 3 ages of hen and 4 storage durations were considered as main factors on albumen quality variables.

MATERIALS AND METHODS

A total of 154 Japanese quail eggs were used to determine influences of hen age (10, 15 and 20 weeks) and storage duration (0, 1, 4 and 7 days). All of the birds were fed and housed under same conditions. All of the storage durations had same conditions (18°C and 60% RH). During sampling or after breaking, cracked, soft-shelled and double-yolked eggs were excluded. Eggs were weighed on an electronic balance to the nearest 100th of a g and then broken onto glass surface. The AH was measured with an electronic micrometer to the 100th of a mm. The thick albumen of each egg was homogenised to measure pH after it was drawn in by a needled syringe.

The pH of the albumens was immediately measured by an electronic pH meter in the same way, to the nearest 100th units. The log of AH was separately evaluated because of the assumption that the logarithm of measurements is normally distributed and taking logarithms are extremely useful because they transform power or geometric relationships into linear relationships and convert multiplicative factors into additive factors (Bagenal, 1955). The HU and the IQU were calculated by using equation as follows:

$$HU = 100 \log [H + 7.57 - 1.7W^{0.37}]$$

$$IQU = 100 \log [H + 4.18 - 0.8989W^{0.6674}]$$

Where:

H = AH in mm

W = EW in g

Data on EW, AH, log of AH, HU, IQU and pH were analyzed using STATISTICA package. A General Linear Model included the main effects of age and storage duration and 2 way interactions between these factors. The correlation coefficients (r) were calculated using Pearson correlation for each combination of age and storage. On the other hand, the correlation coefficients were also compared by Fisher's -r to -z transformation (Papoulis, 1990) when it was needed. The linear regressions of EW and thick albumen quality traits on each other were also investigated. The $p<0.05$ was considered significant for all analyses.

RESULTS AND DISCUSSION

The EW and thick albumen traits are shown in Table 1. While the EW was numerically increasing by the age, it was numerically decreased by the prolonged storage until 7 days but both changes were not significant. Although, age x storage interaction was found to be significant (Table 1), it was not interpreted herein because primary aim of this study was to investigate associations among examined traits. In the same manner, this consideration for all further 2 way interactions of albumen traits will be valid herein.

Table 1: EW and thick albumen characteristics in diverse groups of hen ages and storage durations

Parameters	N	EW	AH	Log of AH	HU	IQU	pH
Age (Weeks)							
10	48	11.990±0.17	4.420±0.09^a	0.641±0.01^a	88.720±0.51^a	58.420±1.05^a	9.35±0.04^a
15	56	12.230±0.13	4.300±0.09^a	0.629±0.01^a	87.830±0.51^a	56.230±1.04^a	9.55±0.05^b
20	50	12.260±0.17	4.010±0.06^b	0.600±0.01^b	86.180±0.41^b	52.680±1.03^b	9.46±0.09^c
Storage (Days)							
	34	12.150±0.20	4.690±0.12^a	0.666±0.01^a	90.040±0.65^a	60.750±1.35^a	8.74±0.05^a
1	35	12.240±0.21	4.470±0.09^b	0.647±0.01^a	88.820±0.48^a	58.320±1.05^a	9.45±0.04^b
4	37	12.340±0.18	4.180±0.08^c	0.618±0.01^b	87.090±0.45^b	54.650±0.96^b	9.70±0.02^c
7	48	11.980±0.14	3.830±0.07^d	0.580±0.01^c	85.280±0.42^c	51.210±1.07^c	9.78±0.02^d
Significance levels							
Age		0.291	<0.001	<0.001	<0.001	<0.001	<0.01
Storage		0.562	<0.001	<0.001	<0.001	<0.001	<0.01
A x S		0.002	0.027	0.036	0.076	0.069	<0.01

Means of each trait with no common superscripts were significantly differed within age or storage columns

The AH was found to be decreased by increased age and storage duration. While only the eggs from 20 weeks age have a lower AH than previous ages, all the ascended levels of storage factor were found to be cause lower AH. It was observed that the age and the storage were similarly affected log of AH. But it must be emphasised that the logarithm of the AH (which is the HU without the correction for EW) caused no difference among eggs from 0 and 1 day storage discrepantly with AH alone. In general both the decreases in AH, log of AH, HU and IQU or the increase in pH denote any deterioration in thick albumen characteristics by the age of hen and/or the storage duration. While as expected the coefficients of variation were generally found to be lower in parameters which are taken logarithm (Table 2), the IQU as another parameter which was included logarithmic transformation had a more relative variation.

Correlation coefficients among EW and examined thick albumen traits were shown in Table 3. Although, high correlations are observed between AH, log of AH, HU and IQU, these will not be interpreted. Because some of them are the same measure on a different scale (AH and log of AH) or both the HU or IQU use AH by a function and this cases lead to high correlation via collinearity or auto-correlation. On the other hand both the correlation coefficients among AH and HU and log of AH and HU were found to be significantly higher than AH and IQU and log of AH and IQU in both age and storage groups.

According to the factorial designed groups, there is no significant association between EW and AH (in the same way as expected between EW and log of AH) except for the eggs from 7 days storage. As above mentioned, HU and IQU use the EW and the AH by assuming different (but fixed) levels of associations among them and both adjusts the AH according to the EW. In this context, these associations need to be compared and to be interpreted. While the correlation coefficients between EW and IQU were only numerically higher than with HU ($p>0.05$) both in the age and the storage on the contrary, the AH was found to be not only numerically but also significantly associated with HU in a stronger manner than with IQU ($p<0.01$ for all).

As expected as a natural result of any deterioration with the age and/or the storage led to negative associations among EW and pH (except for 7 days storage) and AH and pH (or in a different scale log of AH and pH) in an irregular manner.

As it is well known both the HU and the IQU formulas use the EW and the AH to correct AH by egg weight in a logarithmic fashion. Both assume different fixed regressions of the AH on the EW. Besides Kondaiah *et al.* (1983) suggested that the HU and its' fixed regression for chicken eggs does not reflect the association for quail eggs. The regression coefficients with the standard errors of some direct measures of the thick albumen quality variables (non-derived or non-adjusted by any formula such as HU, IQU or albumen indices) on the EW were shown in Table 4.

Table 4 shows that while the regression coefficients of albumen pH on the EW at 10 and 15 weeks of age were only significant, furthermore both had different sign. Regression coefficients of all direct albumen quality measures on the EW were found to be significant in eggs which were only stored 4 days but the regression coefficient of the albumen pH on the EW were negative in a contrary way of the both others. Noteworthily, the R^2 values were found to be quite low and were ranged 8.6-13.6% as representing a low proportion of variation in these response variables that is explained by the regression model.

Table 2: The coefficient of variations for examined traits

Parameters	N	EW	AH	Log of AH	HU	IQU	pH
Age (weeks)							
10	48	9.46	14.68	9.96	4.00	12.48	2.87
15	56	7.96	16.11	10.84	4.31	13.85	3.96
20	50	9.78	11.40	8.36	3.34	13.88	6.46
Storage (days)							
0	34	9.36	14.79	9.81	4.20	12.91	3.17
1	35	10.06	11.54	7.53	3.20	10.68	2.42
4	37	8.94	12.38	8.25	3.14	10.68	1.37
7	48	8.11	11.77	8.87	3.45	14.49	1.53

Table 3: Correlation coefficients between examined traits

Parameters	N	EW and AH	EW and Log (AH)	EW and pH	EW and HU	EW and IQU	AH and Log (AH)	AH and pH	AH and HU	AH and IQU	Log (AH) and HU	Log (AH) and IQU	Log (AH) and pH
All	154	0.133^{NS}	0.134^{NS}	-0.053^{NS}	-0.101^{NS}	-0.329**	0.995**	-0.415**	0.971**	0.884**	0.971**	0.888**	-0.416**
Age (weeks)													
10	48	0.205^{NS}	0.212^{NS}	0.293*	-0.028^{NS}	-0.247^{NS}	0.995**	-0.270^{NS}	0.971**	0.892**	0.970**	0.893**	-0.258^{NS}
15	56	0.235^{NS}	0.244^{NS}	-0.357**	0.053^{NS}	-0.150^{NS}	0.996**	-0.677**	0.982**	0.920**	0.980**	0.920**	-0.668**
20	50	0.023^{NS}	0.018^{NS}	-0.065^{NS}	-0.305**	-0.556**	0.998**	-0.391**	0.944**	0.812**	0.946**	0.818 **	-0.386 **
Storage (days)													
0	34	0.098^{NS}	0.112^{NS}	-0.252^{NS}	-0.121^{NS}	-0.332^{NS}	0.997**	0.429*	0.975**	0.902**	0.972**	0.898**	0.417*
1	35	0.160^{NS}	0.158^{NS}	0.026^{NS}	-0.155^{NS}	-0.436**	0.998**	-0.136^{NS}	0.950**	0.815**	0.950**	0.817**	-0.119^{NS}
4	37	0.349*	0.366*	-0.367*	0.070^{NS}	-0.252^{NS}	0.996**	-0.444**	0.958**	0.814**	0.953**	0.807**	-0.445**
7	48	-0.133^{NS}	-0.129^{NS}	0.208**	-0.392**	-0.592**	0.997**	-0.323*	0.963**	0.872**	0.962**	0.873 **	-0.320*

NS: Not Significant ($p>0.05$); *:$p<0.05$; **:$p<0.01$

Table 4: Regression coefficients of direct measures of albumen quality on the EW

Parameters	AH	Log (AH)	pH
All	0.076±0.046 (0.0180)	0.008±0.005 (0.0180)	-0.022±0.033 (0.00300)
Age (Weeks)			
10	0.115±0.081 (0.0420)	0.012±0.008 (0.0450)	0.068±0.033* (0.0860)
15	0.168±0.094 (0.0550)	0.017±0.009 (0.0590)	-0.139±0.049** (0.128)
20	0.009±0.055 (0.0010)	0.001±0.006 (<0.001)	-0.033±0.073 (0.00400)
Storage (Days)			
0	0.058±0.105 (0.0100)	0.006±0.010 (0.0130)	-0.060±0.041 (0.06400)
1	0.067±0.072 (0.0260)	0.006±0.007 (0.0250)	0.005±0.032 (0.00100)
4	0.164±0.074* (0.122)	0.017±0.007* (0.136)	-0.044±0.019* (0.1350)
7	-0.061±0.068 (0.0180)	-0.007±0.008 (0.0170)	0.032±0.022 (0.04300)

*The R^2 values are in the parentheses

Table 5: The regression coefficients (b±SE) of thick albumen quality parameters on age of the quail hen and storage duration of eggs, the R^2 values and standard errors of the estimates

Parameters	Age of hen	SE of the estimate	Storage	SE of the estimate
AH	-0.041±0.012 (0.06900)	0.61135	-0.117±0.015 (0.274)	0.53966
Log (AH)	-0.004±0.001 (0.06700)	0.06139	-0.012±0.002 (0.282)	0.05385
pH	0.011 ± 0.009^{NS} (0.009)	0.44676	0.118±0.008 (0.559)	0.29808
HU	-0.255±0.069 (0.0820)	3.43078	-0.649±0.087 (0.266)	3.06741
IQU	-0.575±0.151 (0.0870)	7.46441	-1.303±0.196 (0.225)	6.87702

All regression coefficients are significant at $p<0.01$ unless followed by NS and the R^2 values are in the parentheses

The regression coefficients with standard errors of thick albumen quality parameters on age of the quail hen and hatching egg storage duration, the R^2 values and standard errors of the estimates were shown in Table 5. As shown in Table 5, the regression coefficient of the albumen pH on age of the quail hen was merely found to be insignificant and rest of the albumen quality parameters were negatively affected by the hen age increased with low R^2 values. On the other hand, all of the regression coefficients of the albumen quality parameters on storage duration were found to be significant. While the albumen pH increased by increasing storage duration, rest of the other quality parameters were decreased by the prolonged storage. The R^2 values for storage duration were found to be relatively higher and more respectable than for hen age.

CONCLUSION

As well known although both the HU and the IQU were commonly used to measure albumen quality of eggs, actually both has got limitations as a measure of internal quality of eggs. For example, Kondaiah *et al.* (1983) which were developed the IQU formula, observed that the formula arrived as IQU for quail egg has got a limitation for the eggs which are smaller or larger than 9-11 g. On the other hand, many researchers (Eisen *et al.*, 1962; Nestor and Jaap, 1963; Kidwell *et al.*, 1964; Silversides and Villeneuve, 1994) have criticized it and have shown that the adjustment for EW implied by the HU is incorrect except possibly in the sample of eggs measured by Haugh (1937). The statistical association among EW and AH is found to be poor and insignificant except for 4 days storage. It was also observed that either no statistical association or no fixed association among examined traits. It was also concluded that the albumen quality variables must be used without any adjustment. If any formula will use, its limitations must be known and any fixed assumption must be tested for validity in examined conditions.

REFERENCES

Bagenal, M., 1955. A note on the relations of certain parameters following a logarithmic transformation. J. Mar. Biol. Assoc. U.K., 34: 289-296.

Eisen, E.J., B.B. Bohren and H.E. Mckean, 1962. The Haugh unit as a measure of egg albumen quality. Poult. Sci., 41: 1461-1468.

Haugh, R.R., 1937. The haugh unit for measuring egg quality. US Egg Poult. Mag., 43: 552-555.

Kidwell, M.G., A.W. Nordskog and R.H. Forsythe, 1964. On the problem of correcting albumen quality measures for egg weight. Poult. Sci., 43: 42-49.

Kondaiah, N., B. Panda and R.A. Singhal, 1983. Internal egg-quality measure for quail eggs. Indian J. Anim. Sci., 53: 1261-1264.

Li-Chan, E. and S. Nakai, 1989. Biochemical basis for the properties of egg white. Crit. Rev. Poult. Biol., 2: 21-59.

Nestor, K.E. and R.G. Jaap, 1963. Egg weight may influence albumen height. Poult. Sci., 42: 1249-1250.

Papoulis, A., 1990. Probability and Statistics. Prentice-Hall Inc., New Jersey, USA., ISBN-13: 9780137116980, Pages: 454.

Robinson, D.S., 1987. The Chemical Basis of Albumen Quality. In: Egg Quality: Current Problems and Recent Advances, Wells, R.G. and C.G. Belyavin (Eds). Butterworths, London, UK., pp: 171-191.

Silversides, F.G. and K. Budgell, 2004. The relationships among measures of egg albumen height, pH and whipping volume. Poult. Sci., 83: 1619-1623.

Silversides, F.G. and P. Villeneuve, 1994. Is the haugh unit correction for egg weight valid for eggs stored at room temperature? Poult. Sci., 73: 50-52.

Stevens, L., 1996. Egg proteins: What are their functions? Sci. Prog., 79: 65-87.

Williams, K.C., 1992. Some factors affecting albumen quality with particular reference to Haugh unit score. World's Poult. Sci. J., 48: 5-16.