Determining storage related egg quality changes via digital image analysis

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Abstract

The present study was carried out to determine some egg quality characteristics and storage related changes using computer assisted digital image analysis (CADIA) in an 18-month old moulted brown layer (Lohmann Brown) flock. A total of 150 newly laid eggs was randomly divided into two groups: eggs from the control group were broken immediately, while the remainder were stored at 18 ^{o}C and 55% RH for seven days. Area and length measurements related to exterior and interior egg quality were determined by digital image analysis. In general, excluding the outer thin albumen area, all of the area measurements such as total egg content area and inner thick albumen area were larger in stored eggs than in fresh eggs (52.28 *vs.* 49.37 cm^2, 114.36 *vs.* 137.13 cm^2, and 62.08 *vs.* 87.76 cm^2, respectively). Phenotypic correlations between some exterior and interior egg quality characteristics were also determined.

Keywords: Egg quality, moulted brown layer, storage, digital image analysis
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Introduction

Albumen quality is a standard measure of interior egg quality that is most often measured as the height of the inner thick albumen or a function of this, such as the Haugh Unit (Silversides & Scott, 2001). The unit proposed by Haugh (1937) uses a log scale and applies an adjustment for egg weight corresponding to a regression of 0.05 mm/g (Eisen *et al.*, 1962). Silversides & Villeneuve (1994) has criticized the Haugh unit and has shown that the adjustment for egg weight implied by the Haugh unit is incorrect, except possibly in the sample of eggs measured by Haugh (1937). According to the research results, nutrition is relatively unimportant for albumen height, except for a few nutritional factors, with the major influences on albumen height being the strain and age of the hen laying the egg and storage conditions (Hill & Hall, 1980; Silversides, 1994; Toussant *et al.*, 1995; Scott & Silversides, 2000; Silversides & Scott, 2001). In this context it has been proposed simply to measure the height of the inner thick albumen without a correction for egg weight (Silversides & Villeneuve, 1994) or to develop new equations for different poultry species (Kondaiah *et al.*, 1983). It has also been suggested that albumen pH is not biased by the strain and age of the hen and can be used as an alternative method (Silversides & Scott, 2001).

It is well known among consumers that if albumen spreads over a wide area, it generally indicates staleness. However, it is difficult to measure an area that has an irregular shape, and it is also time-consuming. Computer assisted digital image analysis (CADIA) allows repetitive examinations that are accurate and consistent, and often takes less time than that required for manual operations. In addition, CADIA offers the potential for saving labour costs by allowing employees to move from boring, repetitive tasks to more productive ones.

The present study was conducted to determine some egg quality characteristics and storage related changes by CADIA techniques in a layer flock of hens.

Materials and Methods

A total of 150 eggs from an 18-month old moulted brown layer flock (Lohmann Brown) were used for the study. Half of the eggs was broken immediately, and the remainder was stored at 18 ^{0}C and 55% relative humidity (RH) for seven days, and then broken to determine some quality characteristics. Eggs were weighed with an electronic scale (0.01 g sensitivity) and digital images of shelled and broken eggs were obtained by Canon Powershot A70 digital camera. Images were initially saved on a 256 MB Kingston (CF/256) flash card, and then transferred to PC via a USB cable and converted to bitmap images. Image-Pro Express® 4.5 software (MediaCybernetics, Inc., USA, 2003) was used to digitize the samples. During measurement of the quality characteristics via DIA, spatial calibration was applied and renewed for all images to pixels/unit (cm) conversion (Figure 1 and Figure 2) because a fixed tripod was not used during imaging. Measurements included quality characteristics, such as egg width, egg length, egg area (EA) in shelled eggs, and total egg content area (TECA), outer thin albumen area (OTAA), inner thick albumen width, length and area (ITAA), yolk area (YA) and minimum and maximum diameters of the yolk (Figure 3). An equation to represent the "Yolk Circular Deviation Value" (YCDV) was developed, which calculated the deviation of the yolk from perfect circularity. Efil & Sarica (1997) had suggested such modifications for yolk width, due to the fact that the yolk does not take a perfect circular shape when the egg is broken. The YCDV equation is of the type:

$$\text{YCDV}=\left(1-\frac{\text{Minimum Yolk Diameter (cm)}}{\text{Maximum Yolk Diameter (cm)}}\right)\times 100$$

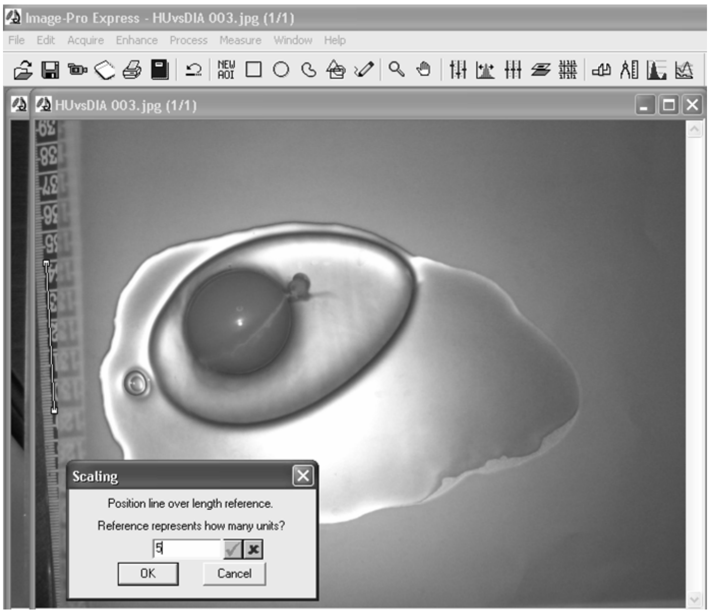


Figure 1 Screen capture of spatial calibration (defining a known measure in digital image)

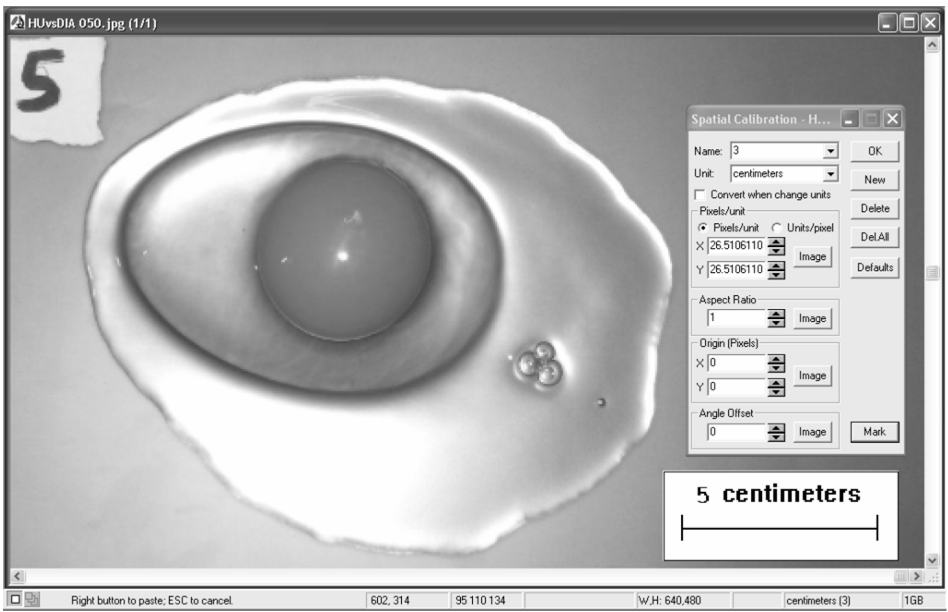
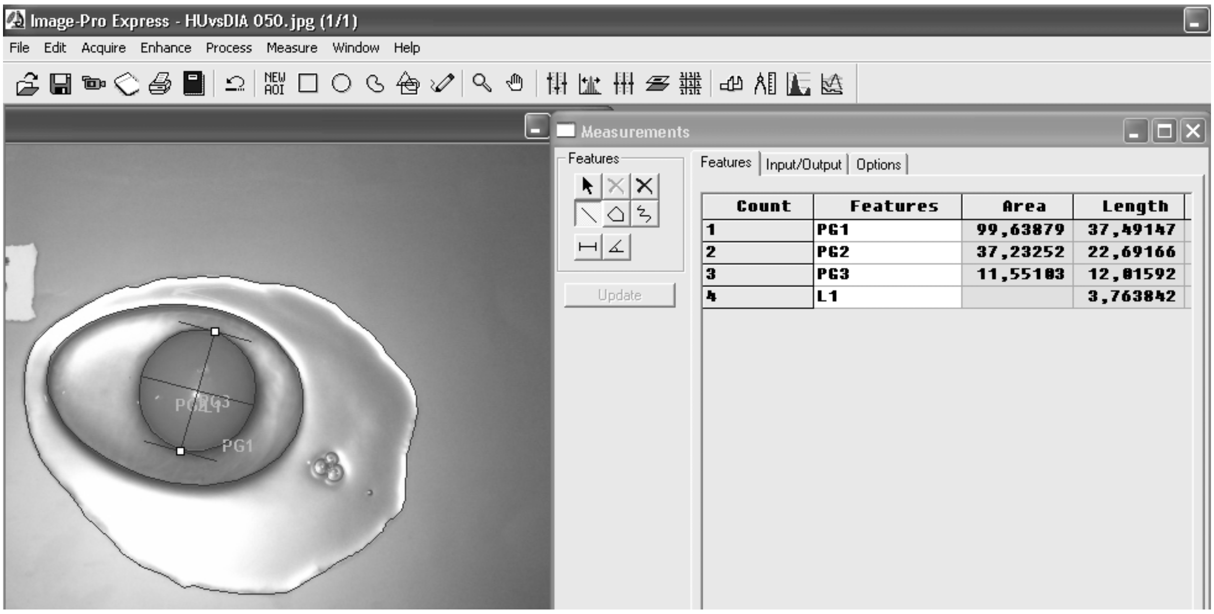


Figure 2 Screen capture of spatial calibration (pixels/unit conversion and marker setting)

Statistical analyses of the data were performed according to the analysis of variance technique, and mean values were separated by Duncans Multiple Range Test. Phenotypical correlations between some of the egg quality characteristics were determined (Duzgunes *et al.*, 1987). Statements of statistical differences were based on P≤0.05 unless otherwise stated. All analyses were performed using SPSS® 10.0 computer software (SPSS Inc., Chicago, USA 1999).

Figure 3 Screen capture of determining polygonal (area) and length measurements



Results and Discussion

Some interior quality characteristics of fresh eggs and those stored at 18 °C and 55% RH conditions for seven days are presented in Table 1. The determined phenotypic correlations between some quality characteristics of fresh and stored eggs are shown in Tables 2 and 3, respectively.

Table 1 Mean (± s.e.) values of some interior egg quality characteristics

Characteristics [1]		Storage duration	
		0 days	7 days
TECA, cm^2	**	114.4 ± 2.09^a	137.1 ± 2.70^b
OTAA, cm^2		52.3 ± 1.58	49.4 ± 2.04
ITAA, cm^2	**	62.1 ± 1.14^a	87.8 ± 2.63^b
YA, cm^2		15.0 ± 0.13	15.0 ± 0.12
YCDV, %	*	4.54 ± 0.28^a	6.14 ± 0.36^b

*: P < 0.01, **: P < 0.001

[a,b] : Within rows, means with no common superscripts differ

[1]TECA - Total egg content area; OTAA - Outer thin albumen area; ITAA - Inner thick albumen area; YA - Yolk area; YCDV - Yolk circular deviation value

All of the area measurement scores, excluding OTAA, were higher in stored eggs than in fresh eggs. Only TECA, ITAA and YCDV scores differed between groups. While inner thick albumen, and hence total egg content spread over a wide area in stored eggs, outer thick albumen spreads over a wide area in fresh eggs. Because the inner thick albumen liquefies during storage, it spreads over a wide area; and most of the weight (humidity) loss during storage occurs from the outer thin albumen that is just beneath the shell, and therefore spreads over a wide area in fresh eggs. This finding illustrates the process of albumen weight loss during storage (Silversides & Scott, 2001). Similarly, while the correlation coefficient between OTAA and

ITAA in fresh eggs was positive, 0.159 (P > 0.05), it was negative in stored eggs, -0.353 (P < 0.01). The high correlation between TECA and YA, OTAA and ITAA is expected because YA, OTAA and ITAA add up to TECA, ($r_{x\ x+y}$). On the other hand, a widened ITAA in stored eggs means decreased albumen height. This supports previous reports (Hill & Hall, 1980; Silversides, 1994; Toussant *et al*., 1995; Scott & Silversides, 2000; Silversides & Scott, 2001).

Table 2 Phenotypic correlations between some quality characteristics in fresh eggs

Characteristics [1]		1	2	3	4	5	6
Egg weight, g	1	-					
EA, cm^2	2	0.878***	-				
TECA, cm^2	3	0.452***	0.470***	-			
OTAA, cm^2	4	0.400***	0.363**	0.841***	-		
ITAA, cm^2	5	0.274*	0.346**	0.667***	0.159	-	
YA, cm^2	6	0.602***	0.593***	0.184	0.147	0.132	-
YCDV, %	7	-0.091	-0.065	-0.115	-0.136	-0.024	-0.062

*: P < 0.05, **: P < 0.01, ***: P ≤ 0.001

[1] EA: Shelled egg area; TECA: Total egg content area; OTAA: Outer thin albumen area; ITAA: Inner thick albumen area; YA: Yolk area; YCDV: Yolk circular deviation value

Table 3 Phenotypic correlations between some quality characteristics in stored eggs

Characteristics [1]		1	2	3	4	5	6
Egg weight, g	1	-					
EA, cm^2	2	0.913***	-				
TECA, cm^2	3	0.379***	0.378***	-			
OTAA, cm^2	4	0.408***	0.337**	0.411***	-		
ITAA, cm^2	5	0.314**	0.127	0.708***	-0.353**	-	
YA, cm^2	6	0.596***	0.494***	0.022	0.147	-0.091	-
YCDV, %	7	0.145	0.209	0.123	0.110	0.040	0.185

**: P < 0.01, ***: P ≤ 0.001

[1] EA: Shelled egg area; TECA: Total egg content area; OTAA: Outer thin albumen area; ITAA: Inner thick albumen area; YA: Yolk area; YCDV: Yolk circular deviation value

In both fresh and stored eggs the yolk deviates from a perfect circular shape, in accordance with the suggestion by Efil & Sarica (1997). More deviations in stored eggs are presumably the result of a weakening of the albumen structure that surrounds the yolk, which normally provides stability to the yolk.

Conclusions

The present study showed that CADIA is a suitable alternative method for determining some exterior and interior egg quality characteristics (based on area, circumference, and also angle and colour measurements). Once the digital images are obtained, measurements and evaluations can be completed at any time. This is a major advantage over the traditional quality measuring techniques. If backing quality measurements, such as colour analysis, are not needed, the required measurements can be carried out with less expensive devices.

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