Quality of Poultry Products
II. Eggs and egg products

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SOME ASPECTS OF DUCK EGG QUALITY

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Abstract

An experiment was carried out with Muscovy ducks to study the influence of age and laying time on egg quality. In addition, the relationships between egg water loss during storage, shell thickness and storage time were tested.

2,920 eggs were collected and individually weighed, washed, fumigated and stored for a maximum period of 7 days. Then the eggs were incubated and candled on the 10th day. All the shells obtained from infertile eggs (10th day), died embryo eggs (10th and 30th day) and hatched eggs (34th day), were immediately cleaned by washing and dried in a forced draught stove. Individual egg measurements included: egg weight at collection and at incubation, shell weight and shell thickness. Shell weight per unit of egg surface area (SWUSA), water loss per unit of time, average shell thickness and percentage of shell weight were calculated.

Results obtained in this study show that the duck egg stored at 11±.2°C and R.H 70-75% loose .03 g of water for each day of storage ($P<.001$). Hatching rate is affected ($P<.05$) by water loss during storage period and the best results (70.34%) are obtained when water loss per week is about 1% of egg weight.

Shell thickness, weight, percentage of shell weight and SWUSA are significantly affected by laying time and age of bird ($P<.01$). These parameters tend to decrease with the progress in laying-period and age of bird. A relationship between hatching outcome and shell weight, percentage of shell weight and SWUSA was observed ($P<.01$).

Moreover results show that although shell weight increases with increasing egg weight ($b=+.082$), it does not increase proportionally. Consequently there is a concomitant decrease in percentage of shell weight ($b=-.028$).

Introduction

Egg quality is one of the most important aspects both for the consumer and to obtain good hatching performance. The quality of the egg is affected by several factors such as: breeding technology, genetics, age of bird, pathology, laying period, storage time and storage environment (Hunton, 1987).

The parameters in use to evaluate the quality of the hatching eggs, in addition to the physical and chemical composition of the different constituents, are based on the measurement of egg water loss, shell thickness, shell index, shell weight and shell porosity (Overfield, 1987; Hunton, 1987; Hamilton et al., 1979). Studies carried out on egg shell quality evidenced the relationship between cracking incidence and shell weight and thickness (Strong, 1989; Overfield, 1987). In addition, a linkage has been demonstrated between shell quality and the age of layers and the time of laying in various domestic birds (Izat et al., 1985; Bagliacca et al., 1986; Delgado et al., 1988; Romboli et al., 1981; Sardà, 1988; Harms et al., 1990; Bagley et al., 1990; Peebles et al., 1987; Yannakopoulos et al., 1986; Nys, 1986).
The easiest method of evaluating these parameters is direct measurement. Since the cracking of the eggs is necessary to obtain most of these measurements, several studies have been carried out to identify indirect methods (Leotta et al., 1987; Nirasawa et al., 1988; Harms, 1989). Indirect methods often require expensive instruments (Hunton, 1987) and are obviously less accurate than direct measurements but they are the only methods employable on hatching eggs.
The present study was performed to investigate the effect of the age of the duck and the laying time, on shell weight and thickness. In addition, since shell thickness has been shown to influence hatching performance (Romboli et al., 1986) and in Italy duck eggs are produced exclusively for hatching, we tested a possible relationship between egg water loss during storage and shell thickness.

Materials and Methods

Thirteen pens of Muscovy ducks were used for the experiment: 7 pens 1 y.o., 3 pens 2 y.o. and 3 pens 3 y.o.
The eggs laid were collected daily during 12 periods of seven days, randomly distributed over the laying season.
All the ducks were reared in the open air under natural light and fed ad libitum with a pellet diet (18% crude protein and 11.5 MJ ME/Kg, a.f.b.).
After collection, eggs were individually weighed, washed (.09% NaCl + 60 ppm ammonium chloride), fumigated (formaldehyde gas) and stored for a maximum period of 7 days (room temperature 11±.2°C and R.H. 70-75%).
A total of 2,920 eggs were incubated (temperature 37.8±.2°C and R.H. 70-75%).
Candling was carried out on the 10th day. Infertile eggs and dead embryo eggs were removed.
On the 30th day fertile eggs were transferred into a hatcher (37.2±.3°C, R.H. 86-88%).
All the shells obtained from infertile eggs (10th day), dead embryo eggs (10th and 30th day) and hatched eggs (34th day), were immediately cleaned by washing and dried in a forced draught stove.

Individual egg measurements included: egg weight at collection and at incubation, shell weight and shell thickness. Shell weight per unit of egg surface area (SWUSA), water loss per unit of time, average shell thickness and percentage of the shell on egg weight were calculated:

- SWUSA was calculated using the equation suggested by Nordstrom and Ousterhout (1982).
- Water loss per unit of time was restricted to the eggs stored for at least 2 days and was obtained from the loss of weight during the storage period divided by the number of days of storage.
- Average shell thickness was obtained, using a micrometer, from the measurement of three pieces of shell with membranes, from the middle, the wide and the narrow end.
- Average shell percentage on egg weight was obtained by dividing the dried shell weight by the weight at collection.

Regression analysis was used to analyze the relationship of water loss with shell thickness, storage time and egg weight, on the infertile eggs during storage. The least squares method was used to analyze the relationship of water loss with storage time on fertile and infertile eggs. The frequencies distribution method was used to analyze the relationship of hatching rate with water loss (five categories) and laying time (three categories: initial, middle and last period; 3 incubations from March to April, 7 incubations from April to July and 2 incubations from August to September). The least squares method was used to analyze shell thickness, shell weight, shell percent on egg weight and SWUSA considering hatching outcome, laying period and age of bird (years) as categorical variables and egg weight as a continuous variable.

Results and Discussion

The relationships, calculated on infertile eggs, of water loss with shell thickness, storage time and egg weight are presented in Table 1.
No relationship is evidenced between egg water loss, shell thickness and egg weight, but egg water loss depends exclusively on the storage period. The estimated b value, calculated on fertile and unfertile eggs, is b=+.031***. Our results are confirmed by Tullet (1987) and Romboli et al. (1989), who evidenced a positive relationship between egg water loss during storage and shell porosity. In fact water loss increases proportionally with increasing number and size of pores and for this reason it can be used as an estimator of egg porosity (Lundy, 1969; Tullet, 1987). Studies carried out on egg quality evidenced both a positive relationship between shell porosity, measured as weight loss, and shell deformation and a relationship between water loss and cracking incidence (Tullet, 1987). Egg water loss depends primarily on shell structure while the effect of shell thickness seems to be so reduced that no relationship between egg water loss during storage and shell thickness is found in our results.

The variations in hatching rate in relationship to water loss during storage and to laying time are shown in Table 2.

Both analyzed variables, water loss categories and laying time, significantly influence hatching rate.
The best hatching rates are observed both with the highest daily water loss (hatching rate: 70.34%) and with the beginning of egg deposition (hatching rate: 72.03%). The trend is similar to that observed in hens. Lundy (1969) and Tullet et al. (1982) reported that the best hatching results are found with an optimum water loss, which is about 1% of egg-weight during storage (Oosterwoud, 1987) and about 10% of egg-weight at hatching (Lundy, 1969). The best results obtained at the beginning of egg deposition, observed also in hens (Lake, 1969), are linked with egg-quality which decreases with the age of the birds.
Significant differences in hatching rate are found between laying times when water losses are from .20 - .045g and the highest values of hatching rate are in the initial period ($P<.01$).
The effects of egg laying time, age of birds, hatching outcome and the egg weight on some parameters of shell quality are shown in Table 3.
Shell thickness, weight, weight percentage of shell and SWUSA are significantly affected by laying time and age of bird. These parameters tend to decrease with progressing laying-period and the age of the bird. The decrease of shell weight and thickness is in agreement with data Romboli et al. (1981) observed in ducks. In this species it was also found (Romboli et al., 1981) that egg weight increases with passing of laying period, as in hens, quail and pheasant (Nys, 1986; Yannakopoulos et al., 1986; Bagliacca et al., 1986). In hens shell quality declines (Roland, 1979) with increasing age and egg size, due to a reduction in ability to absorb Calcium and to produce a strong shell. The decrease in duck shell quality may be due to the same factors.

No significant differences have been found in shell thickness in relationship the hatching outcome. Our results show a relationship between hatching outcome and shell weight, weight percentage of shell and SWUSA . The highest values are in infertile eggs and the lowest in the hatched eggs. This is probably due to the utilization of shell components by the embryo.
There are significant regression b-values between shell weight, weight percentage of shell, SWUSA and egg-weight. There is no significant regression between shell thickness and egg weight. The positive regression between shell weight and egg weight (+.082**) is confirmed by the results obtained in ducks in other research (Romboli et al., 1981).
The increase in egg weight is greater than the increase in shell weight. We observe a negative regression of weight percentage of shell to egg weight. This demonstrates that shell quality declines with the increase in egg weight.
Results obtained in this study show that the duck egg stored at $11 \pm .2$°C and R.H. of 70-75% looses .03 g of water each day of storage. Age of bird and laying time significantly influence the qualitative variables of the shell.

In agreement with results observed in other species, duck egg quality is significantly reduced in advanced deposition (Bagliacca et al., 1986; Izat et al., 1985).

The decline of egg shell quality with progression of laying period is related to a decreasing ability to absorb calcium from the intestine and to mobilize skeletal calcium. In fact the production of the metabolite of vitamin D3, involved in absorption of calcium, is lower in older birds (Tullet, 1987).

Moreover results show that although shell weight increases with increasing egg weight, it does not increase proportionally to the increase in egg weight. Therefore the percentage of shell decreases with increasing egg size.

Water loss during storage has a significant influence on hatching rate.

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Table 1 Relationship between various factors and egg water loss.

Dependent variable	Independent variables	Adjusted squared multiple R
	Shell thickness(ns)	.02
	Storage time(***)	.60
	Egg weight(ns)	.04
Water loss		
	Shell thickness(ns) + storage time(***)	.60
	Storage time(***) + egg weight(ns)	.60
	Shell thickness(ns) + storage time(***) + egg weight(ns)	.61

note: (***) significant regression coefficient ($P < .001$);
(ns) no significant regression coefficient.

Table 2 Effect of water loss per unit of time (g/day) and laying time on hatching percentage.

		Laying time			
		Beginning	Middle	Last	Total
WATER LOSS	≤.020	61.54	66.27	77.42*a*	66.74*ab*
	.020 - .035	75.00A	63.42B	73.08*ab*A	64.80*ab*
	.035 - .045	72.86A	62.03B	51.28*b*B	62.70*b*
	.045 - .060	72.45	65.81	68.42*ab*	67.84*ab*
	.060 - .100	72.41	70.00	62.96*ab*	70.34*a*
Total		72.03 A	64.53 B	66.84 B	

note: means in one row having different capital letters are significantly different ($P < .05$); means in one column having different cursive letters are significantly different $P < .05$.

Table 3 Factors influencing shell thickness, shell weight, shell percentage and SWUSA.

	Thickness µm	Shell Weight g	Percent	SWUSA mg/cm2
Egg-laying time				
Beginning	43.84A	8.98A	13.40A	94.11A
Middle	43.34B	8.82B	13.20B	92.31B
Last	41.59C	8.46C	12.76C	88.27C
Age of bird				
1st y.o	43.41A	8.83A	13.20A	92.33A
2nd y.o	42.67B	8.79B	13.04B	90.91B
3rd y.o	42.69B	8.75B	13.09B	91.05B
Hatching outcome				
Hatched eggs	42.99	7.81C	11.92C	80.66C
Dead embryo	43.04	7.94B	12.08B	82.15B
Infertile eggs	42.74	10.53A	15.35A	111.89A
Egg weight	+.008	+.082**	-.028**	+.097**

Note: means in one column having different capital letters are significantly different $P<.01$;
(**) value significant $P<.01$.

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