Effect of time of oviposition on egg quality characteristics in cages and in a litter housing system

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ABSTRACT: Two experiments were carried out to investigate the effect of the time of oviposition on egg quality characteristics in two different housing systems (cages vs. litter). ISA brown hens from 20 to 64 weeks of age were housed in battery cages (550 cm^2/hen, 19 526 laying hens in the house) and on deep litter (7 hen/m^2, 4 652 laying hens in the house). In both houses, eggs were collected daily at three oviposition times 06:00, 10:00 and 14:00 h. Every four weeks, 90 eggs for each house (30 eggs for each oviposition time) were used for egg quality assessment. The results indicated that in cages the highest percentages ($P \le 0.001$) of normal (74.47%), non-standard (0.85%) and cracked (1.80%) eggs were laid in the early morning (06:00 h). On deep litter, however, the highest percentages ($P \le 0.05$) of normal sound eggs were produced at 10:00 h (35.43%) and at 14:00 h (33.03%). In the cage system, the heaviest eggs (63.01 g) were laid in the early morning (06:00 h) and the highest shell percentage (10.33%) was in eggs laid in the afternoon and also at 10:00 h (10.31%). On the other hand, in the litter housing system, the time of oviposition had no significant effect on egg weight and eggshell quality characteristics except for shell thickness. Morning eggs had greater shell thickness (0.398 mm) than afternoon eggs (0.390 mm). In cages and on litter, statistically significant differences in albumen height, albumen index and Haugh Units were observed between early morning eggs and afternoon eggs and data showed a pattern of relatively higher albumen quality for eggs collected in the afternoon in both systems.

Keywords: cages; deep litter; oviposition time; egg weight; shell quality; albumen quality; yolk quality

Oviposition time plays a vital physiological role in determining eggshell quality because the amount of deposited shell is a linear function of the time spent in the shell gland after plumping, and therefore thickness. In a cage housing system, numerous studies indicated that eggs laid early in the morning were heavier than eggs laid during the later periods of the day (Choi *et al.*, 1981; Arafa *et al.*, 1982; Lee and Choi, 1985; Novo *et al.*, 1997; Patterson, 1997). Moreover, most of investigators revealed that eggs had better shell quality characteristics if laid in the afternoon than in the morning (Roland and Harms, 1974; Arafa *et al.*, 1982; Lee and Choi, 1985; Oguike, 1995; Pavlovski *et al.*, 2000a). On the other hand, Ayorinde and Olagbuyiro (1991) revealed that egg weight was not significantly affected by different times of lay. Furthermore, Aksoy *et al.* (2001) indicated that shell weight was not affected by the collection time.

In recent years in Europe there has been a significant trend to develop and use the litter housing system rather than standard cages. Much of the trend seen today presents an attempt to go back to the natural way of doing things (non-cage) and is driven by local demand and higher prices received for eggs produced in this manner. Results of a number of studies revealed that the proportion of dirty eggs was significantly higher in the aviaries than in the cage system and that the higher proportion of dirty eggs depended on the proportion of floor eggs (Tauson, 1995; Abrahamsson and Tauson, 1995; Abrahamsoon and Tauson, 1998). Moreover, Mohan *et al.* (1991) elucidated that egg weight and shell thickness were higher in birds housed in cages

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than in birds on deep litter. Contrarily, Leyendecker *et al.* (2001) revealed that Haugh units were higher in the aviary system and eggshell thickness was higher in the intensive free-range system than in the battery cages. Similarly, Mohan *et al.* (1991) proved that shape index, yolk index and albumen percentage were significantly higher on deep litter than in cages.

Therefore the objectives of the present study were to determine the effect of oviposition time on egg weight and egg quality traits in cages and in a deep litter housing system.

MATERIAL AND METHODS

Two experiments were carried out to investigate the effect of the time of oviposition on egg quality characteristics in two different housing systems (cages vs. litter). In the first experiment, ISA brown hens from 20 to 64 weeks of age were housed in battery cages (550 cm^2/hen) whereas each cage had 3 hens. The daily photoperiod consisted of 15 h of light and 9 h of darkness. The lights were turned on at 03:00 and off at 18:00 h. In the second experiment, ISA brown hens from 20 to 64 weeks of age were reared on deep litter (7 hens/m^2). The daily photoperiod consisted of 15 h of light and 9 h of darkness. The lights were turned on at 06:00 and off at 21:00 h. Hens were provided with feed and water *ad libitum.* Laying hens were fed commercial feed mixtures N1 (with 17.6% crude protein, 11.7 MJ of metabolizable energy) from 20 to 40 weeks of age and N2 (with 15.5% crude protein, 11.5 MJ of metabolizable energy) from 41 to 64 weeks of age.

In both houses, eggs were recorded, categorized and collected daily at three oviposition times 06:00, 10:00 and 14:00 h. Every four weeks, 90 eggs for each house (30 eggs for each oviposition time) were used for egg quality assessment. Each egg was weighed and the shell-breaking strength was determined by a QCA device (TSS England). Albumen height and Haugh Units were evaluated by a QCD device (TSS England). Using the individual weight of each egg and the weight of its components, percent yolk, percent albumen and percent shell were determined. Yolks were carefully separated without albumen for cholesterol analysis according to Ingr and Simeonovová (1983).

All data were analysed by ANOVA using SAS program. Duncan's multiple range tests is used to differentiate group means.

RESULTS AND DISCUSSION

In the cage system, the time of oviposition had a highly significant ($P \leq 0 .001$) effect on the incidence of egg categories (Table 1). The highest percentage (79.47%) of normal sound eggs was laid in the early morning and a few normal eggs were laid in the afternoon (14:00 h); this result is in correspondence with Choi *et al.* (1981) and Lee and Choi (1985), who reported that a higher proportion of eggs was produced in the early morning. Moreover, Larbier and Leclercq (1994) showed that the majority of eggs were laid in the morning. At the same time, the incidence of non-standard and cracked eggs was higher in the early morning than in the afternoon (Table 1). These results are in coincidence with Halaj and Packa (1977), who noted that the highest occurrence of non-standard eggs (double yolks, small, pointed, spherical, elongated and ring-like) was in the most intensive period of egg laying (9:00 to 11:00 h).

Table 1. Incidence of egg categories as influenced by the time of oviposition in a cage system

Characteristic[1)]	Time of oviposition (h)			Significance
	06:00	10:00	14:00	
Normal eggs (%)	79.47^a	12.35^b	4.91^c	***
Non-standard eggs (%)	0.85^a	0.17^b	0.05^b	***
Cracked eggs (%)	1.80^a	0.28^b	0.09^b	***

[1]The percent values were obtained by dividing the number of eggs for each category during each oviposition time into the total number of eggs produced in the whole day

^{a,b,c}means followed by different letters in the same row are significantly different

***$P \leq .001$

In the litter system, the data in Table 2 show that there were significant ($P \leq 0.05$) differences in the proportion of normal sound eggs laid throughout the day. The highest percentages of normal sound eggs produced in the litter system were at 10:00 h (35.43%) and at 12:00 h (33.03%). These results are in coincidence with Halaj (1974), who indicated that the peak of the egg laying was between 10 and 14 h. Similarly, Washburn and Potts (1975) concluded that the highest percentage of eggs was produced between 10:00 h and 12:00 h. The percentages of non-standard and cracked eggs did not significantly change with oviposition time (Table 2).

The results show large differences between cages and litter system in the laying pattern and these differences may be due to differences in the photoschedules in both houses. Etches *et al.* (1984) noted that the first eggs were laid during the first hours of illumination and that the model time of lay occurred about 5 h after the down signal. These findings are coincident with Etches and Schoch (1984), who postulated that under photoschedules 14L : 10D to 17L : 7D the hens usually lay their eggs in the early morning hours of the photophase.

Based on the results indicated in Table (3), it can be noted that in cages the time of oviposition in-

Table 2. Incidence of egg categories as influenced by the time of oviposition in a litter system

Characteristic[1]	Time of oviposition (h)			Significance
	06:00	10:00	14:00	
Normal eggs (%)	29.61^{b}	35.43^{a}	33.03^{ab}	*
Non-standard eggs (%)	0.34	0.35	0.30	NS
Cracked eggs (%)	0.38	0.36	0.30	NS

[1]The percent values were obtained by dividing the number of eggs for each category during each oviposition time into the total number of eggs produced in the whole day

^{a,b,c}means followed by different letters in the same row are significantly different

^{NS}Non-significant; *$P \leq .05$

Table 3. Effect of oviposition time on egg quality characteristics in a cage system

Characteristic	Time of oviposition (h)			Significance
	06:00	10:00	14:00	
Egg weight (g)	63.01^{a}	61.61^{b}	61.20^{b}	**
Shell strength (N)	43.57	44.17	44.67	NS
Shell deformation (mm)	0.32	0.30	0.30	NS
Shell thickness (mm)	0.389	0.386	0.387	NS
Shell (%)	10.03^{b}	10.31^{a}	10.33^{a}	***
Egg shape index (%)	76.97^{a}	77.01^{a}	76.20^{b}	**
Albumen height (mm)	5.78^{b}	5.75^{b}	5.98^{a}	*
Albumen (%)	62.51	62.82	62.79	NS
Albumen index (%)	7.39^{ab}	7.33^{b}	7.66^{a}	*
Haugh Units	72.68^{b}	73.04^{b}	74.85^{a}	*
Yolk height (mm)	18.42^{a}	17.94^{b}	17.84^{b}	***
Yolk (%)	25.80^{a}	25.31^{b}	25.10^{b}	**
Yolk index (%)	47.27	46.93	46.78	NS
Cholesterol (mg/g yolk)	13.88	14.58	14.36	NS

^{a,b}Means followed by different letters in the same row are significantly different

^{NS}Non-significant; *$P \leq .05$; **$P \leq .01$; ***$P \leq .001$

fluenced significantly egg weight, shell percentage, egg shape index, albumen height, albumen index, Haugh Units, yolk height and yolk percentage. The heaviest eggs (63.01 g) were laid in the early morning (06:00 h) and the egg weights at 10:00 and 14:00 h were 61.61 and 61.20 g, respectively. These results are in accordance with the results of many other researchers (Washburn and Potts, 1975; Choi *et al.*, 1981; Arafa *et al.*, 1982; Lee and Choi, 1985; Novo *et al.*, 1997; Patterson, 1997; Pavlovski *et al.*, 2000a; Aksoy *et al.*, 2001). They proved that afternoon eggs were lighter than morning eggs. Moreover, Choi *et al.* (1981) and Novo *et al.* (1997) showed that egg mass significantly declined with oviposition time. In addition Choi *at al.* (1981) reported that the heavier eggs laid early in the morning were mainly due to the higher percentage of the first eggs of the sequence in a clutch among those laid early in the morning. In a cage system, the time of oviposition plays a very important role in determining eggshell quality. Shell percentage was somewhat higher in the afternoon eggs (10.33%) and also (10.31%) and it significantly decreased in the morning at 06:00 h (10.03%). Similar results were reported by Choi *et al.* (1981) and Novo *et al.* (1997), who noted that shell mass of laid eggs showed a curvilinear relationship with oviposition time, declining during the morning to increase later at the day. On the other hand, Aksoy *et al.* (2001) indicated that shell weight was not affected by the collection time. Other shell quality assessments, shell strength, shell deformation and shell thickness were not significantly affected by the time of oviposition.

Albumen height, albumen index and Haugh Units were significantly higher in the afternoon eggs than in the morning eggs. Haugh Units at 14:00 h (74.85) were higher than at the other collection times. On the other hand, data reported by Pavlovski *et al.* (2000b) documented that eggs laid in the afternoon showed a lower number of Haugh Units. As shown in Table 3, the time of oviposition had a significant ($P \leq 0.01$) effect on yolk percent. Yolk percentage was higher in eggs laid in the early morning (25.80%) than at 10:00 h (25.31%) and at 14:00 h (25.10%). These findings confirm the results of Halaj (1974), who indicated that eggs laid in the morning had a slightly higher ratio of yolk than eggs laid in the afternoon.

In the litter housing system, the time of oviposition had no significant effect on egg weight and most

Table 4. Effect of oviposition time on egg quality characteristics in a litter system

Characteristic	Time of oviposition (h)			Significance
	06:00	10:00	14:00	
Egg weight (g)	62.16	63.27	63.07	NS
Shell strength (N)	47.50	46.94	46.30	NS
Shell deformation (mm)	0.317	0.322	0.310	NS
Shell thickness (mm)	0.398^{a}	0.392^{b}	0.390^{b}	*
Shell (%)	10.37	10.42	10.33	NS
Egg shape index (%)	76.68	76.43	76.08	NS
Albumen height (mm)	5.51^{b}	5.85^{a}	5.86^{a}	**
Albumen (%)	61.91	61.89	61.94	NS
Albumen index (%)	6.86^{b}	7.40^{a}	7.46^{a}	*
Haugh Units	69.99^{b}	72.35^{a}	72.85^{a}	*
Yolk height (mm)	18.50^{a}	18.60^{a}	18.25^{b}	**
Yolk (%)	26.43	26.37	26.00	NS
Yolk index (%)	47.40	48.03	48.01	NS
Cholesterol (mg/g yolk)	14.42	13.93	14.19	NS

^{a,b}Means followed by different letters in the same row are significantly different

^{NS}Non-significant; $^{*}P \leq 0.05$; $^{**}P \leq 0.01$

of egg quality characteristics (Table 4). The heaviest eggs were collected at 10:00 and 14:00 h. Hens laid the heaviest eggs (63.27 g) during the period of 06:00 to 10:00 h. A similar observation was made by Ayorinde and Olagbuyiro (1991), who revealed that egg weight did not differ significantly between eggs laid at different times. This situation does not comply with the findings of many other studies that were carried out in the cage system (Washburn and Potts, 1975; Choi *et al.,* 1981; Arafa *et al.,* 1982; Lee and Choi, 1985; Novo *et al.,* 1997; Patterson, 1997; Pavlovski *et al.,* 2000a; Aksoy *et al.,* 2001). In the litter system, the time of oviposition did not result in any significant differences in shell quality characteristics except for shell thickness. In the morning (06:00 h) collection time, significantly ($P \leq 0.05$) higher shell thickness was observed, whereas thicker shells (0.398 mm) were found on eggs laid during the early morning hours when compared with eggs laid in the afternoon hours (0.390 mm). These findings are not consistent with those of (Roland and Harms 1974; Arafa *et al.,* 1982; Lee and Choi, 1985; Oguike, 1995; Pavlovski *et al.,* 2000b) who indicated that shell quality of eggs laid in the morning was not as good as that of those laid in the afternoon in caged hens. On the other hand, Harms (1991) established that shell weight was highest in the morning, declined until 12:45 h and increased thereafter.

As shown in Table 4, albumen height and albumen index were lower in eggs laid in the morning (06:00 h) and they significantly increased at 10:00 and 14:00 h. The differences in Haugh Units between the last time of oviposition and the first one were 2.86 Units higher in eggs collected in the afternoon. Thus, data showed a pattern of relatively higher albumen quality for eggs collected in the afternoon in the litter housing system. Conversely, Pavlovski *et al.* (2000b) concluded that eggs laid in the afternoon showed a lower value of Haugh Units. In Table 4, no significant differences were detected in yolk percentage, yolk index and cholesterol content between eggs laid early in the morning and those laid late in the afternoon. However, collected eggs at 10:00 h had higher yolk index (48.03%) and lower cholesterol content (13.93 mg/g of yolk). This value of cholesterol content is somewhat lower than the average of yolk cholesterol concentration. Feeley *et al.* (1972) noted an average cholesterol value of 14.8 mg/g of yolk. Hall and Mckay (1993) also reported that the mean yolk cholesterol concentration throughout the first year of egg production was 16.13 mg/g of yolk.

Based on the results of the present study, it can be concluded that in the cage system the heaviest eggs were laid in the early morning and the highest shell percentage was in eggs laid in the afternoon. Data showed a pattern of relatively higher albumen quality for eggs collected in the afternoon. In the deep litter housing system, no significant differences in egg weight and most of eggshell quality characteristics were observed between the three times of oviposition. However, albumen quality assessments in afternoon eggs were better than in morning eggs.

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