The effect of oviposition time and genotype on egg quality characteristics in egg type hens

E. Tůmová, L. Zita, M. Hubený, M. Skřivan, Z. Ledvinka

Department of Animal Husbandry, Czech University of Agriculture, Prague, Czech Republic

ABSTRACT: In an experiment with three strains of Dominant genotype the effect of oviposition on egg quality characteristics was investigated. Laying hens of the Blue strain (group 1), Plymouth Rock (group 2) and their F1 cross (group 3) from 20 to 64 weeks of age were housed on litter (9 birds per m^2). The collection time was at 6.00, 10.00 and 14.00 h. Eggs were gathered in a 28-day interval, every two days all produced eggs (720 eggs in total). The time of oviposition was influenced by genotype. The highest number of eggs was collected in the Plymouth Rock strain at 6.00 (53.5%) and the lowest in the Blue strain at 14.00 (11.1%). There were interactions between the time of oviposition and genotype in egg weight. Eggs laid in the morning at 6.00 were significantly heavier (60.5 g, 64.9 g and 62.1 g) in comparison with eggs laid in the afternoon (59.3 g, 62.4 g and 62.7 g). The heaviest eggs were produced by the Plymouth Rock strain. Significant interactions were observed in eggshell weight when the heaviest eggshell was in afternoon eggs (5.6 g, 5.8 and 5.9 g) and F1 genotype. The egg shape index was also affected by the genotype and time of oviposition. Among the albumen quality characteristics only Haugh Units were influenced by genotype and significantly higher numbers were determined in the Plymouth Rock strain (85.0, 85.3 and 84.7). The genotype significantly affected also the yolk index which was the highest in F1 genotype (45.4%, 45.4% and 44.5%).

Keywords: laying hens; genotype; oviposition time; egg quality

Egg quality comprises a number of aspects related to the shell, albumen and yolk, and may be divided into external and internal quality. The external quality characteristics are evaluated on the basis of eggshell, its cleanness, shape and texture. The internal quality is based on the air cell size, albumen, yolk quality and the presence of blood and meat spots. All egg quality characteristics are affected by several factors, including hen's age, genotype, nutrition and time of oviposition. The genotype influences mainly egg weight and eggshell characteristics. Skřivan (1990), Tůmová et al. (1993), Halaj and Grofík (1994) described main differences in egg weight between white and brown type hybrids. Egg weight also influences eggshell quality. The egg size and the eggshell thickness are highly correlated. The range of the correlation is 0.92–0.97 according to a genotype (Harms et al., 1990). The heritability of eggshell weight is 0.64, eggshell thickness 0.34 and eggshell strength 0.24 (Zhang et al., 2005).

Egg weight and eggshell quality characteristics vary according to the oviposition time. Numerous studies indicated that eggs laid early in the morning were heavier than eggs laid during the later periods of the day (Halaj, 1974; Pavlovski et al., 2000; Ledvinka et al., 2002; Tůmová and Ebeid, 2005). Regarding the shell quality attributes, many studies (Lee and Choi, 1985; Pavlovski et al., 2000; Ledvinka et al., 2002; Tůmová and Ebeid, 2005) showed that eggs had better shell quality if they were laid in the afternoon than in the morning. The time of oviposition also influences yolk weight (Halaj, 1974) and albumen quality (Pavlovski et al., 2000; Tůmová and Ebeid, 2005).

The strongest cue for oviposition time determination in laying hens is light (Lewis et al., 2001)

Supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. MSM 6046070901) and Ministry of Agriculture of the Czech Republic (Project No. 0002701403)

when the circadian rhythm is in association with the preovulatory surges of LH. Lewis et al. (1995) revealed that the mean oviposition time for a brown egg hybrid was 1.2 to 1.4 h earlier than that of a white egg genotype. In the next paper Lewis et al. (2004) recorded the time of oviposition in broiler breeder hens under an 8–16 h photoperiod. The mean oviposition time was delayed in a photoperiod up 14 h but it was similar for a 14 h and 16 h photoperiod. In comparison with modern egg type genotypes, the time of lay was 1 h later than in white-egg hens and 2.5 h later than in brown-egg hybrids. According to Halaj (1982) the longer intervals of egg formation resulted in an increase in egg weight (r = 0.069), albumen weight (r = 0.059), eggshell weight (r = 0.245), eggshell thickness (r = 0.223), shell strength (r = 0.105) and in a decrease in yolk percentage (r = –0.058). Lillpers and Wilhelmson (1993) stated that in three different selection lines (line selected for egg number, line selected for egg mass and line selected for feed consumption) the mean oviposition time was different and affected egg weight. Garces and Casey (2003) studied the effect of oviposition time in dwarf and naked neck laying hens. There was no effect of naked neck gene on oviposition time but the gene was associated with increased yolk weight and reduced albumen height. The dw gene increased the mean time of oviposition, reduced the weight of egg and egg components as well as albumen height.

The aim of the present study was to evaluate the effect of oviposition time in three different genotypes of egg type hens on egg quality characteristics.

MATERIAL AND METHODS

An experiment was carried out with three strains of Dominant genotype, from 20 to 64 weeks of age. Ninety laying hens were split into three groups according to the genotype: genotype one was a Blue strain (B), genotype two was a strain selected from Plymouth Rock (PR) and genotype three was the cross of the Blue (male) strain and female Plymouth Rock (F1). Laying hens were housed in littered pens, 15 hens per pen and 2 pens in a group. The floor space was 9 birds per m^2. The daily photoperiod consisted of 16 h light and 8 h darkness. The lights were turned on at 3:00 h and off at 19:00 h. Laying hens were fed commercial feed mixtures N1 (with 17.8% crude protein, 11.6 MJ of metabolizable energy) from 20 to 40 weeks of age and N2 (with 15.6% crude protein, 11.6 MJ of metabolizable energy) from 41 to 64 weeks of age. Feed and water were supplied *ad libitum*.

In all groups, the number of eggs was recorded daily at three collection times 6:00, 10:00 and 14:00. Every four weeks, for two days, all laid eggs from each pen at each oviposition time were used for egg quality analyses (total 720 eggs). Eggs were weighed, and the shell strength was determined by the shell-breaking method with a QCA device (TSS England). Albumen height and Haugh Units were evaluated with a QCD device (TSS England). The device measures Haugh Units by the method of Haugh (1937). Using the individual weight of each egg and the weight of its components, percent yolk, percent albumen and percent shell were determined. Eggshell weight was determined after drying.

Data on egg quality were evaluated by two-way analysis of variance, genotype and oviposition time interactions using the GLM procedure of SAS (SAS, 2003).

RESULTS AND DISCUSSION

The number of eggs laid at each collection time was influenced by genotype (Table 1), which coincides with findings of Lillpers and Wilhelmson (1993), Garces and Casey (2003) or Lewis et al. (2004), who described differences in the mean oviposition time according to genotype. Plymouth Rock hens laid more eggs early in the morning (until 6:00) whereas in Blue strain and F1 genotypes the time of oviposition at 6:00 and 10:00 was similar.

Table 1. Egg percentage at oviposition time (%)

Genotype	Time of oviposition		
	6:00	10:00	14:00
Blue	45.1	43.7	11.1
Plymouth Rock	53.2	34.3	12.2
F1	43.3	43.5	13.3

Table 2. The effect of oviposition time and genotype on egg weight and eggshell quality

Characteristic	Genotype	Time of oviposition			Significance		
		6:00	10:00	14:00	genotype	time of oviposition	genotype oviposition
Egg weight (g)	Blue	60.5	61.2	59.3	***	NS	**
	PR	64.9	62.9	62.4			
	F1	62.1	60.7	62.7			
Eggshell weight (g)	Blue	5.3	5.5	5.6	***	**	**
	PR	5.7	5.6	5.8			
	F1	5.6	5.5	5.9			
Shell (%)	Blue	8.7	9.0	9.5	**	***	NS
	PR	8.8	8.9	9.3			
	F1	9.1	9.1	9.4			
Shell strength (N)	Blue	41.1	40.4	38.5	NS	**	NS
	PR	39.4	39.4	34.4			
	F1	38.1	39.2	35.5			
Shell thickness (mm)	Blue	0.339	0.333	0.353	***	**	NS
	PR	0.354	0.351	0.380			
	F1	0.356	0.345	0.357			
Egg shape index (%)	Blue	75.8	76.2	76.2	NS	NS	**
	PR	76.1	76.5	76.8			
	F1	76.9	76.6	74.6			

**$P \leq 0.05$; ***$P \leq 0.001$; NS = non significant

It seems that the time of oviposition in F1 genotype was probably more affected by the Blue strain, which was in the male position. In all genotypes, the majority of eggs was laid in the morning, till 10:00, and about 10% was produced till 14:00. In our previous experiment (Tůmová and Ebeid, 2005) with hens on litter, eggs were laid proportionally through the whole day.

Egg weight was influenced highly significantly ($P \leq 0.001$) by genotype (Table 2). The heaviest eggs were from Plymouth Rock hens whereas the lightest were from the Blue strain. The time of oviposition did not significantly affect egg weight, which is in agreement with our previous results (Tůmová and Ebeid, 2005). There were significant interactions between the genotype and the time of oviposition. The Blue strain laid the heaviest eggs at 10:00, the Plymouth Rock at 6:00 and F1 at 14:00. The significantly highest egg weight was recorded in Plymouth Rock eggs laid at 6:00 and the lowest in the eggs of Blue strain laid at 14:00.

The oviposition time plays a very important role in determining eggshell quality. All eggshell quality characteristics, eggshell weight, shell percentage, eggshell strength and eggshell thickness (Table 2), were significantly better in afternoon eggs in comparison with eggs laid in the morning. These results correspond with studies of Lee and Choi (1985), Novo et al. (1997), Pavlovski et al. (2000), Ledvinka et al. (2002), Tůmová and Ebeid (2005), who reported a linear relationship of eggshell quality with the time of oviposition. The effect of genotype on eggshell quality was also confirmed. Eggshell weight, strength and thickness were higher in eggs of the Plymouth Rock than in the Blue strain or F1. A significant interaction ($P \leq 0.05$) between the genotype and time of oviposition was found only in eggshell weight.

Significant interactions ($P \leq 0.05$) were also observed in the egg shape index (Table 2), which increased with the time of oviposition while the highest values were indicated in the afternoon except F1 genotype. A significant effect of oviposition on the egg shape index was found out in eggs produced in cages but the highest numbers were at 10:00 whereas on litter the egg shape index was not influenced (Tůmová and Ebeid, 2005).

The albumen is a major indicator of the overall internal egg quality. There were no interactions be-

Table 3. The effect of oviposition time and genotype on albumen and yolk quality

Characteristic	Genotype	Time of oviposition			Significance		
		6:00	10:00	14:00	genotype	time of oviposition	genotype oviposition
Albumen weight (g)	Blue	36.7	37.2	35.9	NS	NS	NS
	PR	36.2	38.4	37.8			
	F1	37.3	36.4	38.2			
Albumen (%)	Blue	60.4	60.6	60.4	NS	NS	NS
	PR	60.5	6.9	60.5			
	F1	59.8	59.7	60.7			
Albumen index (%)	Blue	9.5	9.8	9.5	NS	NS	NS
	PR	8.8	9.9	9.7			
	F1	9.3	9.8	9.0			
Haugh units	Blue	85.0	85.3	84.7	**	NS	NS
	PR	81.2	82.6	85.3			
	F1	82.7	84.7	81.2			
Yolk weight (g)	Blue	17.4	17.3	16.6	NS	NS	NS
	PR	17.8	17.7	17.4			
	F1	17.9	17.6	17.4			
Yolk (%)	Blue	28.8	28.4	26.1	NS	NS	NS
	PR	29.8	28.2	27.9			
	F1	29.1	29.2	27.9			
Yolk index (%)	Blue	42.7	43.9	41.5	***	NS	NS
	PR	45.5	44.5	43.8			
	F1	45.4	45.4	44.5			

**$P \leq 0.05$; ***$P \leq 0.001$; NS = non significant

tween the time of oviposition and genotype in albumen weight, albumen percentage, albumen index and Haugh Units (Table 3). Haugh Units are used as the main albumen quality characteristic, and in contrast with our previous experiments (Tůmová and Ebeid, 2005) this characteristic was not influenced by the time of oviposition where we had found significantly higher values of Haugh Units in afternoon eggs in comparison with morning eggs. Only in eggs laid by Plymouth Rock, Haugh Units were insignificantly higher in afternoon eggs in comparison with morning eggs. In the Blue strain and F1 the Haugh Units were not influenced by the time of oviposition. Neither did Ledvinka et al. (2002) record the effect of oviposition on Haugh Units in meat type hens. On the other hand, Pavlovski et al. (2000) documented that eggs laid in the afternoon showed a lower number of Haugh Units. It seems that there are many factors which influence albumen quality linked to the time of oviposition. Haugh Units were significantly affected by genotype. The highest values were determined in the Blue strain.

Yolk quality is mainly related to yolk weight and yolk index. Yolk index was highly significantly higher in F1 genotype in comparison with the Blue or Plymouth Rock strains but there were no differences in the oviposition time or interactions. Yolk weight and/or yolk percentage slightly decreased with the time of oviposition in all genotypes, which corresponds with the findings of Halaj (1974) and Tůmová and Ebeid (2005), who reported that eggs laid in the morning had a slightly higher ratio of yolk than eggs laid in the afternoon.

To sum up the results of the experiment, the time of oviposition seems to depend on genotype. There may be a different time of oviposition in the genotype which afterwards influences egg quality characteristics, mainly egg weight and egg shell parameters. Interactions between the genotype and the time of oviposition show this relationship that could be in other egg quality characteristics as well.

REFERENCES

Garces A., Casey N.H. (2003): Oviposition and egg quality traits of dwarf and naked neck layers. S. Afr. J. Anim. Sci., 33, 105–110.

Halaj M. (1974): Study of dynamics of egg laying and properties during a day. Acta Zootech., 28, 162–171.

Halaj M. (1982): The effect of length of egg production on some their properties. Acta Zootech., 38, 196–203. (In Czech)

Halaj M., Grofík R. (1994): The relationship between egg shell strength and hens features. Živoč. Výr., 39, 927–934.

Harms R.H., Rossi A.F., Sloan D.R., Miles R.D., Christmas R.B. (1990): A method for estimating shell weight and correcting specific gravity for egg weight in egg shell quality studies. Poult. Sci., 73, 599–602.

Haugh R.R. (1937): The Haugh Unit for measuring egg quality. US Egg Poult. Mag., 43, 552–555, 572–573.

Ledvinka Z., Skřivan M., Tůmová E., Dlouhá G. (2002): The effect the age and hens oviposition time on quality of eggs for hatching. In: Proc. Conf. Sustainable Development of Crop and Animal Production. Way of Development of Czech Countryside. September 25–26, 2002, Prague. 110.

Lee K.D., Choi J.H. (1985): Interrelationships among time of oviposition, egg weight, shell weight, and rate of production of laying hens. Poult. Sci., 64, 2256–2258.

Lewis P.D., Perry G.C., Morris T.R. (1995): Effect of photoperiod on the meat oviposition time of 2 breeds of laying hens. Br. Poult. Sci., 36, 33–37.

Lewis P.D., Backhouse D., Gous R.M. (2004): Photoperiod and oviposition time in broiler breeders. Br. Poult. Sci., 45, 561–564.

Lewis P.D., Perry G.C., Morris T.R., English J. (2001): Supplementary dim light differentially influences sexual maturity, oviposition time and melatonin rhythm in pullets. Poult. Sci., 80, 1723–1728.

Lillpers K., Wilhemson M. (1993): Genetic and phenotypic parameters for oviposition pattern in 3 selection lines of laying hens. Br. Poult. Sci., 34, 297–308.

Novo R.P., Gama L.T., Soares M.C. (1997): Effects of oviposition time, hen age and extra dietary calcium on egg characteristics and hatchability. J. Appl. Poult. Res., 6, 335–343.

Pavlovski Z., Vitorović D., Skrbić Z., Vracar S. (2000): Influence of limestone particle size in diets for hens and oviposition time on eggshell quality. Acta Vet. Beograd, 50, 37–42.

SAS (2003): Institute Inc.. The SAS System for Windows. Release 9.1.3

Skřivan M. (1990): Performance of Contrast Types of Laying Hens in Largescale Production. Czech University of Agriculture Prague, 77 pp. (In Czech)

Tůmová E., Ebeid T. (2005): Effect of time of oviposition on egg quality characteristics in cages and in a litter housing system. Czech J. Anim. Sci., 50, 129–134.

Tůmová E., Skřivan M., Mandák K. (1993): Technological value of eggs of Hisex Brown and D 29 laying hens. Sborník VŠZ v Praze, AF, Řada B, 55, 245–251. (In Czech)

Zhang L.C., Ning Z.H., Xu G.Y., Hou Z.C., Yang N. (2005): Heritability and genetic and genotypic correlations of egg quality traits in brown-egg dwarf layers. Poult. Sci., 84, 1209–1213.

Received: 2006–08–08
Accepted after correction: 2006–10–04

Corresponding Author

Prof. Ing. Eva Tůmová, CSc., Department of Animal Husbandry, Czech University of Agriculture, Prague, Czech Republic
Tel. +420 224 383 048, e-mail: tumova@af.czu.cz