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Effect of lemon juice on the egg shell quality of layers subjected to heat stress

Hadi Tavakkoli[1*], Seyede Saeedeh Masallanejad[2], Sajedeh Salandari[3]

[1] *Department of Avian Medicine, School of Veterinary Medicine, Shahid Bahonar University of Kerman, Kerman, Iran*
[2] *Graduate student, School of Veterinary Medicine, Shiraz University, Iran*
[3] *School of Veterinary Medicine, Shahid Bahonar University of Kerman, Kerman, Iran*

Abstract

Heat stress is an effective factor on immune responses, body weight, egg production and egg quality of chickens. The major effect of heat stress is due to decreased food intake and alteration in acid-base balance. During the recent years, efforts to improve laying performance at high temperatures have been relatively successful. Supplementation of the diet or drinking water with special nutrient has been proposed as a means to reduce the effects of heat on the layer hens. There is scantly information about the effects of natural compounds on the heat-stressed hens. In this regard, the aim of the present study was to determine the effect of lemon juice on egg shell quality in layers subjected to hot climate. 50-week-old commercial layer chickens were divided into 2 equal treatment groups of 2400 birds each. Each treatment has three replicates. The experimental groups were fed as follows: in the control and test groups (groups A and B), birds were fed a standard diet. In the test group (group B), 5 ml/L of lemon juice was added to the drinking water for 30 days. At the end of each week, eggs with broken and fragile shell were recorded. Our results showed that the addition of lemon juice in drinking water was significantly reduced eggs with broken and fragile shells during heat stress ($P<0.05$). Based on findings, it is concluded that lemon juice can be considered as a natural supplement to alleviate heat stress in laying hens under hot climate.

Key words: Heat stress, Hot climate, Layer, Lemon juice

Introduction

Poultry meat and eggs will often rank as the highest-quality human foods. They are important sources of protein in many areas of the world. In recent years, the poultry industry has a leading role among agricultural industries in many parts of the world. The Iranian poultry industry has experienced tremendous development and expansion during the past twenty years. On the other hand, some of the Iranian poultry farms have been located in the hot regions. Most breeders in these regions are aware of the rapidity with which the poultry industry can be developed in those areas. They are also aware of the contribution that this industry can improve the economic status of their country. Although the need for more eggs and poultry meat is obvious in hot regions, there are several constraints to the future development of the poultry industry in these areas. The most obvious constraint on poultry production in these areas is the climate. High temperature imposes severe stress on birds and leads to reduced performance (Quinteiro-Filho et al. 2010; Lara and Rostagno 2013). Several studies have been conducted on the effects of high temperature on the immune responses, body weight, egg production and egg quality

Corresponding Author E-mail: Tavakkoli@uk.ac.ir

of chickens (Mashaly et al. 2004; Oguntunji and Alabi 2010; Brake and Yahav 2011). Fortunately, during the recent years, efforts to improve laying performance at high temperatures have been relatively successful. Methods include supplementation of the diet or drinking water with special nutrient, housing practices and development in the management protocols (Daghir 2008; Ajakaiye et al. 2010; Marques et al. 2011; Bozkurt et al. 2012). However, problems associated with egg production and egg shell quality have proved difficult to resolve. Although nutritional strategies have been proposed as a means to reduce the effects of heat on layer hens, there is little information that addresses the effects of natural compounds on heat-stressed hens. In this regard, the present study was conducted to determine the effect of lemon juice on egg shell quality in layers subjected to hot climate. We believe that this investigation may further help us to use a natural additive of plant origin in the poultry industry.

Materials and Methods

50-week-old commercial layer chickens (Hy-Line W-36) were randomly divided into 2 equal treatments A and B groups of 2400 birds each. Each treatment group was further sub-divided into three replicates of 800 birds per replicate. The mean rate of lay was 83% at the beginning of the experiment. The presence and level of lemon juice in drinking water were the main factor tested. The experimental groups were fed as follows: in the control and test groups (groups A and B), the birds were fed a standard diet. In the test group (group B), 5 ml/L of lemon juice was added to the drinking water and the control group received water without any additives. Feed and water were available ad-libitum. The ingredients of standard diet are presented in table 1.

Table 1: Ingredient and chemical composition of the standard diet (%)

Ingredients	(%)
Corn	64.35
Wheat	5.50
Soybean meal (44%CP)	14. 7
Vegetable oil	0.40
Fish meal	4.00
Dicalcium Phosphate	0.36
Ground Limestone	9.70
NaCl	0.35
DL-Methionine	0.07
L-Lysine	0.02
Choline	0.05
Vitamin Premix *	0.25
Mineral Premix*	0.25
Total	100
Analysis	
Crude protein	15.00
Ca	3.70
P	0.33
Methionine	0.38
Lysine	0.77
ME, Mcal/kg	2.80

*Vitamin/Mineral Premix (Talavang) supplied per 5 kg: vitamin A, 11000000 IU; cholecalciferol, 5000000 IU; vitamin E, 7 500 IU; K3, 3000 mg; vitamin B1, 3000 mg; vitamin B2, 8000 mg; niacin, 4000 mg; d-pantothenic acid, 15555 mg; vitaminB12, 16 mg; folic acid, 2000 mg; biotin, 150 mg, Mn, 120000 mg; Fe, 40000 mg; Zn, 100000 mg; Cu, 16000 mg; iodine, 125 mg; Se, 300 mg; cholinchloride, 900000 mg.

In a cage brooding system, five birds were kept in separate cages. The temperature was 35-37°C during the laying period. A photoperiod of 16 h/day was maintained. The experiment was carried out in a hot region was located in the Fars province of Iran, in July. The trail was lasted for 30 days.

Measurements

The eggs were collected daily. Eggs with broken and fragile shell were also collected and recorded weekly.

Statistical analysis

Statistical analysis was performed using SPSS version 20. The Chi-Square test was used to determine the significant differences between experimental groups. A P-value of <0.05 was considered as statistically significant.

Results

The effects of lemon juice on the egg shell quality (eggs with broken and fragile shell) of layers maintained at high temperature are given in Tables 2 and 3. The analysis of data at the start of the experiment (weeks 1 and 2) showed that there was no significant difference in egg shell quality between experimental groups, while it was different significantly from weeks 3 to 4 ($p<0.05$). The best value was observed in the layers of group B which treated with 5 ml/L of lemon juice in drinking water. The addition of lemon juice in drinking water was significantly reduced eggs with broken and fragile shells.

Table 2: The total egg production and eggs with broken and fragile shell of layers maintained at high temperature.

Weeks	Control group		Test group (lemon juice in drinking water)	
	Total egg production (Mean ± SEM)	Eggs with broken and fragile shell (Mean ± SEM)	Total egg production (Mean ± SEM)	Eggs with broken and fragile shell (Mean ± SEM)
1	662.41 ± 0.97	34.96 ± 0.16	663.74 ± 1.16	34.50 ± 0.25
2	656.07 ± 0.62	34.04 ± 0.20	659.92 ± 0.62	33.13 ± 0.33
3	658.32 ± 0.24	36.64 ± 0.27	663.54 ± 0.81	27.75 ± 0.49
4	656.97 ± 0.84	35.37 ± 0.12	661.41 ± 0.71	26.82 ± 0.22

Values are mean ± SEM.

Table 3: The effect of lemon juice on the eggs with broken and fragile shell (%)

Weeks	Control group	Test group (lemon juice in drinking water)	P values
1	5.27 ± 0.01[a]	5.15 ± 0.02	NS
2	5.18 ± 0.02	4.98 ± 0.03	NS
3	5.56 ± 0.04	4.23 ± 0.06	S
4	5.38 ± 0.01	4.01 ± 0.02	S

[a]Percentage of the eggs with broken and fragile shell, NS: Non-significant ($p>0.05$), S: significant, Values are mean ± SEM.

Discussion

Most of the major international poultry breeders are located in temperate countries such as Canada, France, Germany, the Netherlands, the UK and the USA. Nevertheless, much of the world's poultry production takes place under hot climate. In these regions, often humidity conditions are extreme and the temperature is over 35°C in some seasons. For many years, researchers have been investigating the effect of high ambient temperatures on the performance of different poultry species, including quail (Sahin and Kucuk 2003; Sahin et al. 2006; Halıcı et al. 2012), turkeys (Renaudeau et al. 2011; Yahav et al. 2011), young chickens (Mahmoud and Edens 2005; El-Habbak et al. 2011; Willemsen et al. 2011; Ashraf et al. 2013; Montanhini Neto et al. 2013), broilers (Hasheimi et al. 2012; Sohail et al. 2012; Sakomura et al. 2013; Sohail et al. 2013) and laying hens (Deng et al. 2012; Irandoust et al. 2012). Their results established that high environmental temperatures have adverse effects on the production performance. In laying hens, heat stress decreases protein digestion, body weight, egg production, egg weight and shell quality. Heat exposure is generally accompanied by suppression of feed intake. Whereas egg production and egg weight are influenced by the reduction in feed consumption, egg shell quality is influenced primarily by high temperature (Daghir 2008; Bozkurt et al. 2012). Furthermore, the status of $Ca2^{+}$, and ability of gastrointestinal cells to transport calcium could be important factors in the detrimental effects of heat stress on performance and egg shell characteristics in laying hens (Mashaly et al. 2004). On the other hand, hyperventilation, the respiratory alkalosis and alterations in acid-base balance that occur when hens are located at high temperature cause in the loss of carbon dioxide from the blood and associated losses of bicarbonate from the blood and body fluids. A reduced bicarbonate concentration in the lumen of the shell gland adversely affects egg shell quality. Therefore, it is possible that, at high temperatures, the hens have a nutritional requirement to reduce heat stress (Lin et al. 2006; Daghir 2008; Lara and Rostagno 2013). The current experiment was conducted to evaluate the effect of lemon juice on the egg shell quality of hens are located at high temperature. Our study showed that the addition of lemon juice in drinking water was significantly reduced eggs with broken and fragile shells. This result agrees with those of researches suggest that at high temperature laying hens need special nutritional requirement to improve egg production and egg shell quality (Puthpongsiriporn et al. 2001; Lin et al. 2006; Deng et al. 2012; Irandoust et al. 2012). Lee et.all (1998) showed that dietary supplementation with extra vitamin E can alleviate the adverse effects of chronic heat stress in laying hens. It was also shown that a diet with mannan-oligosaccharide or essential oil mixture provided increment in the egg shell quality of laying hens (Bozkurt et al. 2012).

In our study, the useful effect of lemon juice on the egg shell quality of heat-stressed bird could be due to ingredients such as ascorbic acid content of lemon juice. Ascorbic acid is the most-studied vitamin in relation to heat stress (Abidin and Khatoon 2013; Mahmoud et al. 2013). Njoku and Nwazota (1989) found that the ascorbic acid could improve food intake and food utilization in layers. There is some evidence, which indicates that during high environmental temperatures, birds are not able to synthesize sufficient ascorbic acid to replace the severe losses of this vitamin (Daghir 2008). Ahmad et al. (1967) showed that ascorbic acid limited the increase of body temperature during heat stress up to 35ºC. Supplemental ascorbic acid has also been reported to improve heat resistance and reduce mortality associated with elevated ambient temperature (Pardue et al. 1984). In laying hens, ascorbic acid supplementation was shown to improve egg production, egg weight and egg shell thickness (Daghir 2008). Nevertheless, little is known about the useful effects of lemon juice on the layer performance, subjected to high temperatures and no well-described experimental model exists. Further efforts are needed to evaluate the usage of lemon juice under this newfound aspect.

Conclusion

The results of the present study indicate that adding lemon juice to drink water during the period of egg formation has advantage on the egg shell quality at high temperature. Based on the poultry industry's

development during the last decades and the need to increase in animal protein sources, it is suggested that lemon juice can be considered as a natural supplement to alleviate heat stress in laying hens in the hot climate.

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