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Original research paper

QUALITY OF HEN'S EGGSHELL IN CONDITIONS OF HIGH TEMPERATURES

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ABSTRACT: In this paper was examined the influence of high temperatures on eggs which originated from a poultry farm situated at the south of Republic of Macedonia. In this region the average summer temperatures are always higher than the average summer temperatures in the rest of the country. The experiment lasted for 9 months and comprised a period of three seasons: summer, autumn and winter. Layers were two different ages: younger – up to 40-week of age, and older – over 40-week of age. All production parameters of the flocks were recorded: production of eggs, mortality, feed-consumption, body weight and the percentage of broken and cracked eggs during the research. 50 eggs monthly out of each age group were examined, or more exactly, 877 eggs of both age groups up to the end of the experiment. An analysis of egg mass, eggshell mass and percentage of calcium carbonate in the eggshell was performed. At the end of the research the results were statistically processed according to method of the Least Squares Means. High temperatures in the region had highly significant influence ($p<0.01$) over egg size, which was 2.16 g smaller than the average. The heat stress showed high significance ($p<0.01$) concerning the percentage of calcium carbonate into the egg shell, which in the summer months was the lowest and ran to 90.74%, in the autumn months it ran to 92.01%, and during the winter months it was the highest, 93.86%. The percentage of broken and cracked eggs per month was the highest in the summer period. It ran 1.92% to 3.29% in different ages of layers. The received results in this way proved the negative effect, caused by the heat stress on the quality of eggshell.

Key words: *high temperatures, hen, eggshell, calcium carbonate*

INTRODUCTION

Avian eggshell is containing organic (3.5%) and inorganic (95%, almost calcium carbonate) phases; it weighs about 5 g and contains 2.2 g of calcium, which represents about 38% of its weight (Nys et al., 1999). Many factors have been found to affect eggshell quality such as strain, management, disease, nutritional status of the flock, environmental temperature, stress and age (Roberts, 2004). One of the mayor factors contributing to poorer eggshell quality is hot weather and inadequate feed intake. Temporary thinning of the eggshell may occur during periods of high temperatures (above 25 ˚C) since feed intake is reduced. The shells quickly regain normal thickness when temperatures are reduced and feed intake increases. Deficiency of calcium will negatively affect the shell quality. Economic losses associated with the incidence of eggshell defects are important when evaluating the profitability of a layer operation

(Bell, 1998). High ambient temperature resulted in a significant increased eggshell breakage (Lin et al., 2004). Low egg quality leads to nearly 5-8% loss at production (Keshavarz, 1994). The frequency of defective eggs may increase from 7-11% during laying, collecting and packing phases of egg production. Increasing the temperature above 21˚C usually causes deterioration in shell quality, particularly if humidity is also high (Peterson, 1965). Excessive heat during summer results in a small eggs or eggs with poor shell quality, because the high environmental temperatures reduces hen's appetite (Sauveur and Picard, 1987; Webster, 2002). Appetite reduction is not only consequence of heat stress. Hens pant and its evaporates water from the respiratory tract, so the carbon dioxide is removed from the blood at a higher rate than normal. That is change the acid-base balance of the blood to a higher pH and carbonate ions becomes less available to form calcium carbonate, which is the major component of the eggshell. Excessive panting can contribute to reduced shell quality (Mueller, 1966).

The aim at the present study was to determine the influence of high temperatures on the eggshell quality of hen`s eggs.

MATERIAL AND METHODS

In this research the eggs from the poultry farm in south of Macedonia are used as material, where the Mediterian climate temperatures influence is occurred. The high summers temperatures are ordinary and normal emerge, and also they are higher from the average of summer temperatures from the rest country regions (35-40˚C). The trial obtains the summer, autumn and winter season in the time lasting of nine (9) months, in which period the daily maximum and minimum temperatures were followed, as well as the relative humidity too.

The eggs for the examination were taken from three layer flocks from ISA- BROWN line, with different age during the research period, where all the production parameters were evidenced: mortality, body weight, feed consumption, egg production and a number of broken and cracked eggs. The egg production and the cracked eggs evidence were comprised in three phases: the first phase, reached the first five months, the second phase, was featured by the next five months, and finally, the last two months of annual egg production, were covered by the third phase. The layer flock's feeding was adequate to their age and season. The main aim was to lower influence of the nutrition factor, under the eggshell quality changes.

From the two groups of produced eggs, first one was from 40 weeks age layers or younger layers, and the second group eggs were from under 40 weeks age or older layers. 50 eggs from both groups were collected monthly for examination for egg weight, shell weight and percentage of $CaCO_3$ (calcium carbonate) in the eggshell, under the laboratory conditions, by a Cramer titrimetric method.

Statistical analysis

The data was arranged by the method of smallest squares with assistance of statistic program "Mixed Model Least "– squares and maximum likelihood computer program".

RESULTS AND DISCUSSION

The average of temperatures has reached their maximum in the summer period, mainly in July, with 26.7˚C, and the minimum in December with amount of 6.3˚C. The winter period has reached the highest relative humidity in December with 85.2 %, while in July the amount of relative humidity has reached 47.5%, which is counted as a high for that time of year. As previously mentioned, high ambiental temperatures and high relative humidity, leads to depression of feed consumption reduced layer performances, (Sturkie, 1946) and decrease the loss of evaporated heat in layers, aspired to decrease the body temperature (Sykes and Fataftah, 1986).
In table 1 are illustrated production results of layer flocks, participated in the trial.

Table 1. Production performance of the tested flocks

Parameters	Flocks			Average (monthly)
	I	II	III	
1. Number of hens in flock				
- At the beginning of the year	18.389	18.412	18.394	18.398
- At the end of the year	17.498	17.762	17.507	17.589
2. Mortality				
- Total mortality number of birds	891	650	887	67.42
- % of mortality birds	4.85	3.53	4.82	0.37
3. Produced eggs per hen				
- First phase of production	120.97	132.73	138.94	26.18
- Second phase of production	119.15	125.32	129.04	24.90
- Third phase of production	45.45	44.95	47.72	23.02
-Average per hen	285.57	303.00	315.70	25.12
- Moved in per hen	279.78	298.55	310.66	24.69
4. Broken and cracked eggs yearly, %				
- First phase of production	0.93	1.96	1.01	1.29
- Second phase of production	2.37	3.20	2.02	2.53
- Third phase of production	3.36	3.41	3.30	3.36
5. Feed consumption per hen				
-Average consumption, yearly, kg	43.18	43.68	42.37	43.08
- Average consumption daily, g	118.30	119.67	116.08	118.02
- Average production per egg, g	151.20	144.16	134.24	143.19
6. Body weight of hen				
- At the beginning, g	1.820	1.800	1.730	1.783
- At the end, g	2.005	2.182	1.995	2.061
- Total increasing of the weight, g	185	382	265	278

In the first phase, the egg carrying capacity rapidly grows, and distinguishes the peak of production over 90% which continued in the next few months, in average of 26.18 produced eggs monthly. The percentage of broken and cracked eggs was the lowest, 1.29 % due to highest ability for calcium retention from the feed of the younger layers, with amount over 2.0 g daily (Hurwitz and Griminger, 1962).

In the second phase, egg production has shown a slow trend of decrease in range of 88% toward 75%, as well as the increased and maintained egg weight, at the same time.

Monthly, the average of produced eggs was 24.90 while the broken and cracked eggs amount in this phase was increased and its amount was 2.53% because of the decreased Ca retention from 1.5 to 1.7 g/per bird/daily. Increased necessity of Ca for bigger eggs production, and decreased Ca retention on the other side, contributes to weaker eggshell production, consequence by increased cracked egg production.

The third phase consists of eleventh and twelfth month of egg production year, featured by egg carrying decrease to 68% and the average number of eggs monthly was 23.02, followed by maximum egg weight. The number of cracked eggs in this phase, was the biggest, (3.36 %), because of older layers age and if it took a parallel trend with extreme high environmental temperatures, the percentage of the broken and cracked eggs should be increased.

Hot ambient temperature may reduce the activity of carbonic anhydrase enzyme which results in the formation of bicarbonate which contributes carbonate to the eggshell (Balnave et al., 1989) hence formation of eggs with poor shell quality by hyperthermic hens, furthermore insufficient circulating Ca level has been linked with production of eggs with poor shell quality in heat-stressed hens. Chauhan and Roy (2007) suggested that hot ambient temperature influences low feed intake which will simultaneously effect reduction in dietary Ca intake, mobilization and availability, and contribute directly to poor shell quality. The graphic (Figure 1) show the influence phase production on eggshell quality.

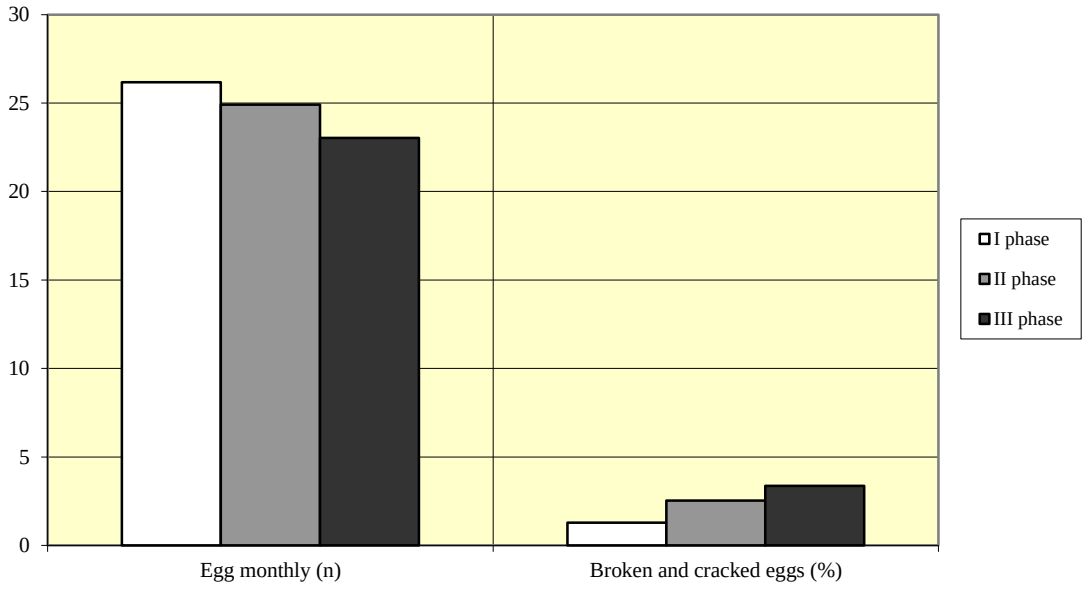

Figure 1. Graphic present monthly average production of eggs and percentage of broken and cracked eggs by phases

The younger hens (I phase) had produced mostly eggs with fewer cracks at the beginning of lying, while the older layer (II and III phase) at the end of their laying had low produced of eggs and the number of cracked eggs was growing. All this means that with the hen's age, the quality of laying eggs was lower and the strength of eggshell was decreased. In our researching almost were not differences in the eggshell weight to

young and adult hens, which are not corresponding with most conclusions by authors whose has claimed that with aging of hens the eggshell weight was increasing. However, all this can be explained with the fact that layers have limit for calcium retention which is amount 50% from total food intake. The average retaining is around 2.2 g calcium. By the process of egg's forming, this quantity of Ca is distributed in the eggshell. Because of the fact that as younger, layers produces smaller eggs, it followed that these eggs are with very strong eggshell, for reason that the quantity of 2.2 g calcium is arranged on the smaller area. But with the aging of layers, they are laying larger eggs and the same quantity of calcium is arranging on bigger area, which results with forming of thinner eggshell.

In our researching were investigated 877 eggs because to consolidate the effect of season (SEZ) on egg mass (MJ), eggshell weight (LMT) and proportional content of calcium carbonate ($LCaCO_3$) in eggshell. Since the results were statistically worked out, it was created a table (Table 2) in which is shown the importance of the influences of the fixed factors.

Table 2. Effect of seasons on egg mass, eggshell weight and percentage of calcium carbonate in eggshell

Fixed factor	n	MJ Egg mass, g		LMT Eggshell weight, g		$LCaCO_3$% Calcium Carbonate, %	
		LSM	SE	LSM	SE	LSM	SE
μ	877	64.62	0.085	8.21	0.036	75.19	0.103
SEZ							
1 Summer	279	62.46	0.152	8.17	0.085	90.74	0.436
2 Autumn	297	65.71	0.150	8.22	0.073	92.01	0.391
3 Winter	301	65.71	0.151	8.23	0.071	93.86	0.357
Fexp		156.32**		0.14		15.63**	

MJ - Egg mass, g; ST- Eggshell weight; $LCaCO_3$ - %; LSM - Least Squares Means; SE- Standard error ($p<0.01$)** ($p<0.05$)*

The season had high significant effect on egg mass, so in summer period was obtain mass value for 2.16 g lower than the general average. This is proving that in summer period, the hens were producing eggs with less mass. Extremely high temperatures were reducing the layer appetite, in the way that they were not able to carry in all the nutritious matter, so this deficit causes minor eggs.

Egg mass depends of hereditary traits, hen age, season and feed consumption (Stadelman and Pratt, 1989). Our results had showed more influence of external temperatures on egg mass, as well as May and Stadelman (1960) have had pointed that season have significant influence on the egg mass. Deaton (1982) with own investigations showed that the egg mass was reducing in summer period at constant temperatures from 15 to 35˚C, until 2 g at the younger hens and until 1 g at the older hens in dependence of the egg mass average. The authors Peguri and Coon (1991) have established the significant decreasing of layer appetite from 11 g daily, on the occasion of increasing external temperature to 31˚C and egg mass was decreased for 1.82 g.

The influence of factor season on eggshell weight was not showed significant difference, although in summer months eggshell mass was same lighter (8.17 g), while in winter

months it was heavier (8.23 g), so these difference were not significant. In conditions of relative humid from 40 to 70% and high temperature (25-35˚C) has been concluded significant decreasing of egg mass, eggshell weight and shell thickness as significant increasing of egg cracks (Yahav et al., 2000).

The influence of season on content of calcium carbonate in eggshell was showed a high significant ($p<0.01$). The most difference from average values was appeared in summer months when percentage of calcium carbonate was the lowest (90.74%), while the most percentage was in winter months (93.86%). Different of 3.12% between summer and winter season is proved that problems about construction eggshell quality are happened in conditions of high temperatures and heat stress. Bragg et al. (1971) have considered that factor as reduced calcium secretion, reduced calcium transportation in eggshell gland or decline value of bicarbonate ions under the influence of respirator alkaloses, may be in narrow connection with decline eggshell quality in time of high temperatures.

The major negative effect of heat stress is presented of decreased feed consumption, which is reason for declined proceeds of calcium in organism. Inadequate quantity of accepted calcium affected on decline of egg mass, eggshell weight and decreased of eggshell quality for the most important reasons (Roland et al., 1996).

CONCLUSIONS

It can be concluded that the influence of the summer season, especially high temperatures, had negative effects on the quality of eggshell and with that, it had negative effects on the whole egg production in that period of the year, while both aging of hens and hot ambient temperatures had effect on decline of calcium retention and increase of number of broken and cracked eggs.

REFERENCES

BALNAVE, D., YOSELLEWIZ, I. and DIXON, R. (1989) Physiological changes associated with the production of defective eggshells by hens receiving sodium chloride in the drinking water. *British Journal of Nutrition,* **61:** 35-53.

BELL, D. (1998) Eggshell quality-its impact on production, processing and marketing economics. Proceedings of 14th Alltech Annual Symposium, pp. 447-466.

BRAGG, D.B., FLOYD, J. and STEPHENSON, E.L. (1971) Factors affecting the transfer of calcium from the hen's diet to the egg shell. *Poultry Science,* **50:**167-173.

CHAUHAN, H.V.S., and ROY, S. (2007) Nutritional diseases, in: (Eds) *Poultry Diseases Diagnosis and Treatment*, Vol. 3, pp. 172 (New Delhi, Ltd., New Age International).

DEATON, J.W., REECE, F.N., Mc.NAUGHTON, J.L. and LOTT, B.D. (1982) Effect of heat stress on laying hens acclimated to cyclic and constant temperature. *Poultry Science,* **61:** 875-878.

HURWITZ, S. and GRIMINGER, P. (1962) Egg production and shell quality in temperature and light controlled in uncontrolled environment. *Poultry Science,* **41:** 499-508.

KESHAVARZ, K. (1994) Laying hens respond differently to high dietary levels of phosphorus in monobasic and dibasic calcium phosphate. *Poultry Science,* **73:** 687-703.

LIN, H., MERTENS, K., KEMPS, B., GOVAERTS, T., DE KETELAERE, B., DE BAERDEMAEKER, J., DECUYPERE, E. and BUYSE, J. (2004) New approach of testing the effect of heat stress on eggshell

quality: Mechanical and material properties of eggshell and membrane. *British Poultry Science,* **45:** 476–482.

MAY, K.N. and STADELMAN, W.J. (1960) Some factors effecting components of eggs from adult hens. *Poultry Science,* **39:** 560-565.

MUELLER, W.J. (1966) Effect of rapid temperature changes on acido-base balance in shell quality (abstract). *Poultry Science,* **45:** 1109.

NYS, Y., HINCKE, M., ARIAS, J.L., GARCIA-RUIZ, J.M. and SOLOMON, S.E. (1999) Avian eggshell mineralization. *Avian and Poultry Biology Reviews,* **10:** 142-166.

PEGURI, A. and COON, C. (1991) Effect of temperature and dietary energy on layer performance. *Poultry Science,* **70:** 126-138.

PETERSON, C.F. (1965) Factors influencing eggshell quality-A review. *World's Poultry Science Journal,* **21:** 110-138.

ROBERTS, J.R. (2004) Factors Affecting egg internal quality and eggshell quality in laying hens. *The Journal of Poultry Science,* **41:** 161-177.

ROLAND, D.A., BRYANT, M.M. and RABON, H.W. (1996) Influence of calcium and environmental temperature on performance of first cycle commercial Leghorns. *Poultry Science,* **75:** 62-68.

STADELMAN , W.J. and PRATT, D.E. (1989) Factors influencing composition of the hen's egg. *World's Poultry Science Journal,* **45:** 247-266.

STURKIE, P.D. (1946) The effects of hypotermia upon the reproductive tract of the hen. *Poultry Science,* **25:** 369-378.

SUVEUR, B. and PICARD, M. (1987) Environmental effect on egg quality, in: WELLS, R.G. and BELAYAVIN, C.G. (Eds) *Egg Quality-Current Problems and Recent Advances*, pp. 219-234 (Butterworths, London, UK).

SYKES, A.H. and FATAFTAN, A.R.A. (1986) Effect of change in environmental temperature on heat tolerance in laying fowl. *British Poultry Science,* **27:** 307-316.

WEBSTER, A.B. (2002) Things to remember to preserve egg quality during summer. *Ph.D. Thesis,* University of Georgia.

YAHAV, S., SHINDER, D., RAZPAKOVSKI, V., RUSAL, M. and BAR, A. (2000) Lack of response of laying hens to relative humidity of high ambient temperature. *British Poultry Science,* **41:** 660-663.