Review on Agriculture and Rural Development 2014. vol. 3 (1) ISSN 2063-4803

COMPARISON OF CHANGES IN THE BONE MINERAL CONTENT AND EGG SHELL WEIGHT AND EGG SHELL RATIO IN BROWN AND WHITE EGG LAYERS DURING THE FIRST EGG LAYING PERIOD

ESZTER SZENTIRMAI[1], GÁBOR MILISITS[1], TAMÁS DONKÓ[1], GYÖRGY KOVÁCS[3], ZOLTÁN BUDAI[2], JOLÁN UJVÁRI[1], IMRE REPA[1], ZOLTÁN SÜTŐ[1]

[1]Kaposvár University
Faculty of Agricultural and Environmental Sciences
H-7400 Kaposvár, Guba Sándor u. 40., Hungary
[2]Bábolna Tetra Ltd.
H-9651 Uraiújfalu, Petőfi Sándor u. 18., Hungary
[3]University of Debrecen, Faculty of Informatics
H-4028 Debrecen, Kassai út 26., Hungary
milisits.gabor@ke.hu

ABSTRACT

In this experiment computer tomography (CT) was used to follow the changes in the bone mineral content of laying hens and to examine its correlation with egg shell quality in brown and white egg layers during the first egg laying period. The experiment was carried out with 45 TETRA SL (brown egg layer) and 45 TETRA BLANCA (white egg layer) hens, which were scanned four-weekly by a Siemens Somatom Emotion 6 multislice CT scanner between 20 and 72 weeks of age. The CT measurements consisted of overlapping 10 mm thick slices covering the whole body of the hens. The estimation of the bone mineral content (BMC) was perfomed by scanning phantoms with hydroxyapatite densities equal to 0 and 200 mg/cm^3 and Hounsfield units of the bones (101-550) were linearly converted into hydroxyapatite densities. Based on the results it was established that changes in the bone mineral content of the laying hens showed an increasing tendency during the experimental period in both examined genotypes. Changes were parallel in both of the examined genotypes, but the measured values were mostly higher in the TETRA BLANCA hens than in the TETRA SL layers. Similar tendency was observed also in the changes of the egg shell weight in both genotypes. However, despite of the similar changes in bone mineral content and egg shell weight, only very low correlation was found between these traits in both examined genotypes (r=0.118 in the TETRA SL and r=0.173 in the TETRA BLANCA hens, respectively). Based on the results it was concluded that computer tomography seems to be useful tool for the *in vivo* examination of changes in the bone mineral content of laying hens. However, the low correlation coefficients between the bone mineral content and egg shell weight in this study indicate that instead of the whole bone structure of the hens only the examination of those bones seems to be needed, which are in close connection with the egg shell formation.

Keywords: hen, bone, egg shell, computer tomography

INTRODUCTION

In former studies it was already established that the bone and eggshell quality of laying hens is significantly affected by the keeping and nutritional conditions (LEYENDECKER ET AL., 2002; SILVERSIDES ET AL., 2012; JIANG ET AL., 2013). Because the close correlation between bone and eggshell quality was also pointed out in former experiments (KIM ET AL., 2012), bone quality was studied by different methods (chemical, biomechanical and computer tomography) in some former experiments (RICZU ET AL., 2004; STREUBEL ET AL., 2005; MARTINEZ-CUMMER ET AL., 2006; TOSSENBERGER ET AL., 2011).

However, this examinations were mainly done at given ages of the hens and, therefore, only less informations are available about the changes of bone quality during the egg laying period. Because in some former experiments computer tomography was established as a new useful tool for evaluating bone density in laying hens, this *in vivo* technique was used in this experiment to follow the changes in the bone mineral content of laying hens and to examine its correlation with egg shell quality during the first egg laying period.

MATERIAL AND METHOD

The experiment was carried out with 45 TETRA SL (brown egg layer) and 45 TETRA BLANCA (white egg layer) hens, which were kept in cages (1,800 cm² basic area), in a closed building at the Poultry Test Station of the Kaposvár University, Faculty of Agricultural and Environmental Sciences, in Hungary. In order to the correct identification, of which egg was produced by which hen, hens were assigned individually with wing tags and two hens (one TETRA SL and one TETRA BLANCA) were placed into one cage. The hens were fed *ad libitum* with commercial diets during the whole experimental period (*Table 1.*). Drinking water was also continuously available from self-drinkers.

Table 1. Composition of the diets used in the experiment

Component	Content
Dry matter (g/kg)	903.4
ME Poultry (MJ)	11.56
Crude protein (g/kg)	177.8
Crude fat (g/kg)	43.0
Crude fibre (g/kg)	43.1
Crude ash (g/kg)	47.6
Nitrogen-free extractives (g/kg)	591.9
Sodium (g/kg)	1.7
Lysine (g/kg)	8.7
Methionine (g/kg)	3.9
Methionine + cystine (g/kg)	7.0
Calcium (g/kg)	37.6
Phosphorous (g/kg)	7.0

Changes in the hens' bone mineral content and egg shell weight and egg shell ratio were monitored four-weekly, between 20 and 72 weeks of age. The bone mineral content of the birds was always determined *in vivo* by means of computer tomography (CT) at the Institute of Diagnostic Imaging and Radiation Oncology of the Kaposvár University.

During the CT scanning procedures birds were fixed with belts in a special plexi-glass container, without using any anaesthetics. Three animals were scanned simultaneously. Due to the special arrangement of the hens, they were separable on the CT images, therefore their bone mineral content was determined individually.

The CT measurements consisted of overlapping 10 mm thick slices covering the whole body using a Siemens Somatom Emotion 6 multislice CT scanner. Following scanning parameters were set in: 130 kV – 80 mAs, spiral data collection (pitch 1), FoV 500 mm. The images obtained were evaluated by means of OpenIP software package (KOVÁCS *et al.*, 2010). The estimation of the bone mineral content (BMC) was perfomed by scanning phantoms with hydroxyapatite densities equal to 0 and 200 mg/cm^3 and Hounsfield units of the bones (101-550) were linearly converted into hydroxyapatite densities.

After the CT measurements, all of the eggs, which were produced by these birds on the CT examination days, were weighed and broken. After breaking the eggs the weight of the shell was measured and its ratio to the whole egg weight was calculated.

For the statistical evaluation of the differences in the bone mineral content, egg shell weight and egg shell ratio between the examined genotypes, the Independent Samples t-test was used. For testing the correlation between the bone mineral content of the hens and the egg shell weight, Pearson correlation coefficients were calculated. Both statistical analyses were carried out by the SPSS statistical software package, version 10.0 (SPSS for Windows, 1999).

RESULTS AND DISCUSSION

Examining changes in the bone mineral content of the laying hens it was established that it showed an increasing tendency during the experimental period in both examined genotypes (*Figure 1.*).

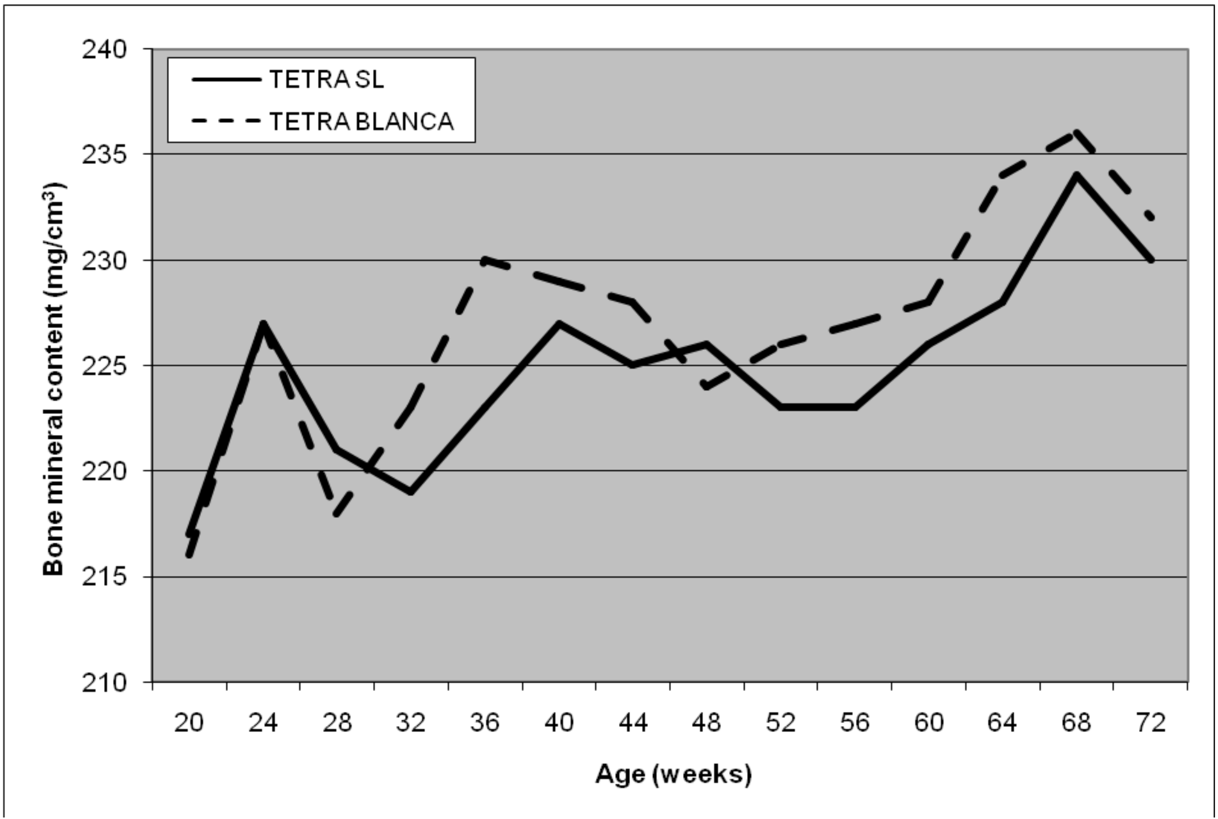

Figure 1. Changes in the bone mineral content of TETRA SL and TETRA BLANCA laying hens during the first egg laying period

The bone mineral content increased from 217 to 230 mg/cm^3 in the TETRA SL hens and from 216 to 232 mg/cm^{3}in the TETRA BLANCA hens between 20 and 72 weeks of age. Changes were parallel in both of the examined genotypes, but the measured values were mostly higher in the TETRA BLANCA hens than in the TETRA SL layers. However, significant differences were found only at 32, 36 and 64 weeks of ages ($P<0.05$).
Similar tendency was observed also in the changes of the egg shell weight in both genotypes (*Figure 2.*).

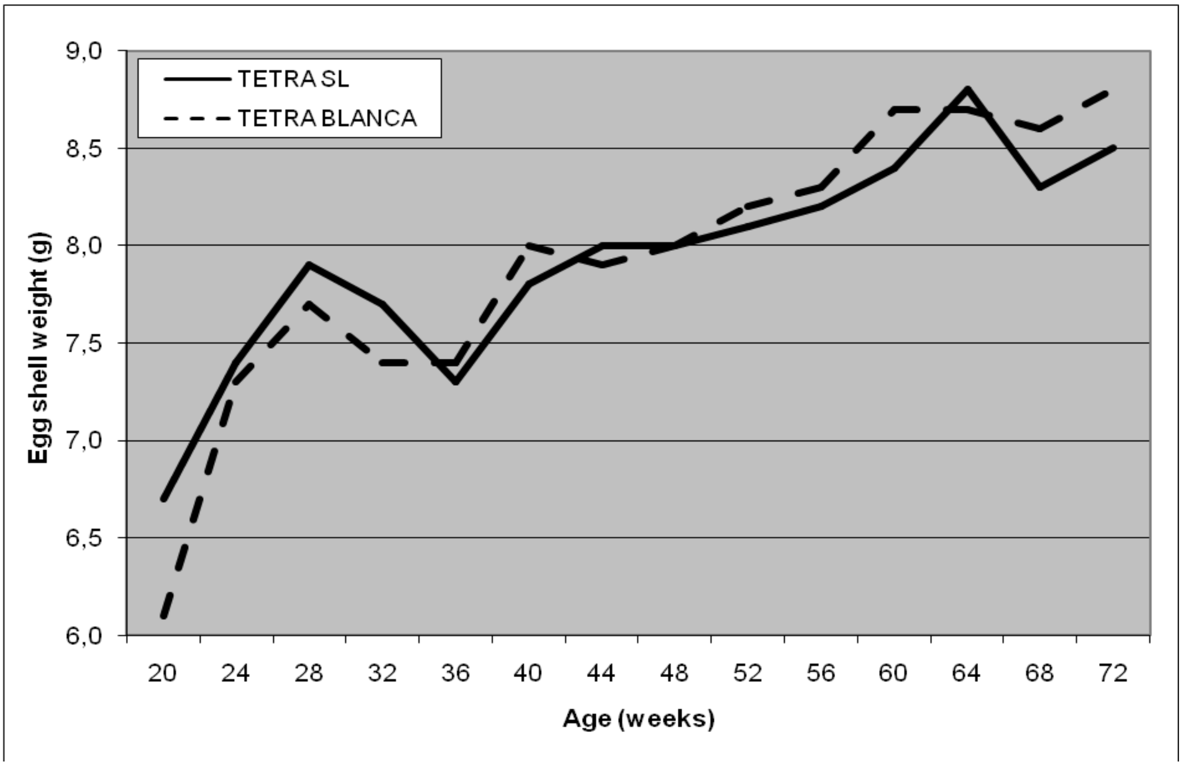

Figure 2. Changes in the egg shell weight of TETRA SL and TETRA BLANCA laying hens during the first egg laying period

The egg shell weight increased from 6.7 to 8.5g in the TETRA SL hens and from 6.1 to 8.8g in the TETRA BLANCA hens during the examined period. Similarly to the changes in the bone mineral content, the higher increase was observed in the TETRA BLANCA hens also in this case. While the egg shell weight increased by 44.3% in TETRA BLANCA hens, it's increase was only 26.9% in the TETRA SL hens between 20 and 72 weeks of age. Significant differences were not observed between the genotypes in this case.

Because of the similar changes in bone mineral content and egg shell weight, the correlation between these traits was tested as next step of the data evaluation. By calculating the Pearson correlation coefficients it was established that only a very low – but highly significant ($P<0.001$) – correlation exists between these two traits in both genotypes ($r=0.118$ in the TETRA SL and $r=0.173$ in the TETRA BLANCA hens, respectively).

When the ratio of egg shell weight to the whole egg weight was calculated, a decreasing tendency was observed in both genotypes between 20 and 36 weeks of age (*Figure 3.*). The egg shell ratio decreased from 14.0 to 12.0% in the TETRA SL hens and from 14.6 to 13.1% in the TETRA BLANCA hens during this period. This ratio remained almost the same in the case of TETRA BLANCA hens, while it increased slightly in the case of TETRA SL hens between 36 and 72 weeks of age. The higher values were observed in the eggs of TETRA BLANCA hens during the whole experimental period. Significant differences between the examined genotypes were pointed out from 24 to 40 weeks of age ($P<0.001$).

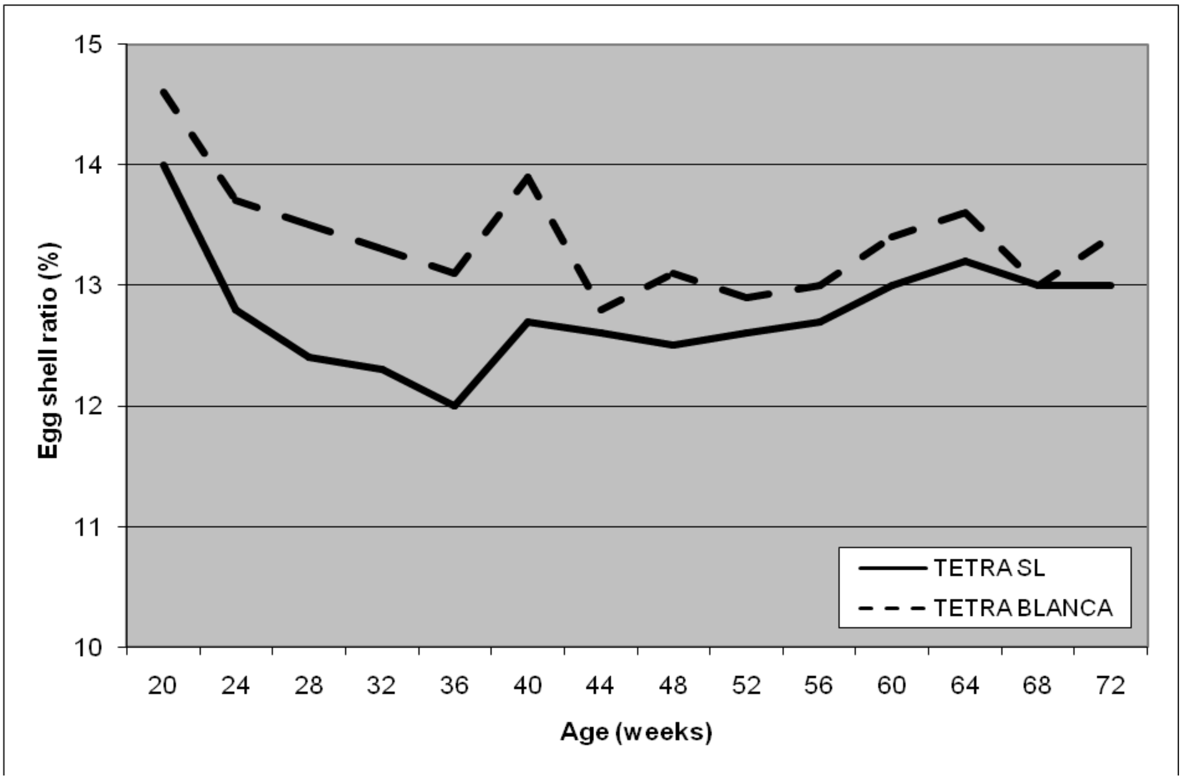

Figure 3. Changes in the egg shell ratio of TETRA SL and TETRA BLANCA laying hens during the first egg laying period

CONCLUSIONS

Based on the results it was concluded that computer tomography seems to be useful tool for the *in vivo* examination of changes in the bone mineral content of laying hens. However, the low correlation coefficients between the bone mineral content and egg shell weight in this study indicate that instead of the whole bone structure of the hens only the examination of those bones seems to be needed, which are in close connection with the egg shell formation. The development of the suitable method for this examination could be the main goal of the further experiments.

ACKNOWLEDGEMENTS

This research project was supported by the National Office for Research and Technology (TETRAKAP-TECH_08_A3/2-2008-0394).

REFERENCES

JIANG, S., CUI, L., SHI, C., KE, X., LUO, J., HOU, J. (2013): Effects of dietary energy and calcium levels on performance, egg shell quality and bone metabolism in hens. Veterninary Journal, Volume 198. Number 1. pp. 252-258.

KIM, W.K., BLOOMFIELD, S.A., SUGIYAMA, T., RICKE, S.C. (2012): Concepts and methods for understanding bone metabolism in laying hens. World's Poultry Science Journal, Volume 68. Number 1. pp. 71-82.

KOVÁCS, GY., IVAN, J. I., PANYIK, A., FAZEKAS, A. (2010): The openIP open source image processing library. Proc. of ACM Multimedia 2010 International Conference, pp. 1489-1492. (ISBN: 978-1-60558-933-6), Firenze (Italy), October 25-29. 2010

LEYENDECKER, M., HAMANN, H., HARTUNG, J., GLUNDER, G., NOGOSSEK, N., NEUMANN, U., KAMPHUES, J., DISH, O. (2002): Analysis of the egg shell stability and the bone strength of laying hens in three different hen housing systems. Züchtungskunde, Volume 74. Number 2. pp. 144-155.

MARTINEZ-CUMMER, M.A., HECK, R., LEESON, S. (2006): Use of axial X-ray microcomputed tomography to assess three-dimensional trabecular microarchitecture and bone mineral density in single comb white leghorn hens. Poultry Science, Volume 85. Number 4. pp. 706-711.

RICZU, C.M. SAUNDERS-BLADES, J.L., YNGVESSON, A.K., ROBINSON, F.E., KORVER, D.R. (2004): End-of-cycle bone quality in white- and brown-egg laying hens. Poultry Science, Volume:83, Number 3. pp. 375-383.

SILVERSIDES, F.G., SINGH, R., CHENG, K.M., KORVER, D.R. (2012): Comparison of bones of 4 strains of laying hens kept in conventional cages and floor pens. Poultry Science, Volume 91. Paper 1. pp. 1-7.

STREUBEL, R., BARTELS, T., KRAUTWALD-JUNGHANNS, M.E. (2005): Computed tomography assisted, chemical and biomechanical studies on bone density and breaking strength in laying hens. Archiv für Geflügelkunde, Volume 69. Number 5. pp. 206-212.

TOSSENBERGER, J., TENKE, J., DONKÓ, T., REPA, I., HORÁK, A., TISCHLER, A., KÜHN, I. (2011): The effect of phytase and phosphorus supply on different bone parameters estimated by computer tomography in broilers. European Symposium on Poultry Nutrition, Izmir (Turkey), 31 October – 4 November 2011.