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Development of new image evaluation software and its applicability in the in vivo prediction of egg yolk content in hen's eggs depending on some CT aquisition parameters

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ABSTRACT

The present study was designed to determine the in vivo predictability of egg yolk content in hens' eggs by means of computer tomography (CT), depending on some aquisition parameters. The experiment was carried out with altogether 120 eggs, which were originated from a 36 week old TETRA-H parent stock. During the CT measurements eggs were positioned in egg holders (10 eggs), thus two eggs were scanned simultaneously. The scanning parameters were: 80–110–130 kV and 40–80–120 mAs in 9 possible combinations, spiral mode, pitch 1, field of view 110 mm. In all cases eggs were scanned using overlapping 3 mm slice thickness on a Siemens Somatom Emotion 6 multislice CT scanner. On the images obtained the volume of the yolk was determined using a self-developed egg-separation and segmentation software. After the CT measurements eggs were broken and their yolk weight was measured. Pearson correlations were calculated between the CT predicted yolk volume and the measured yolk weight. It was established that the higher tube voltage settings of 110 and 130 kV resulted in higher correlation (r=0.78–0.79) between these two examined traits than the lower voltage setting of 80 kV (0.75–0.76). The X-ray dose (mAs) had no significant effect on the correlation coefficients. Based on these results it was concluded that further development of this method is needed in order to obtain the similar accuracy of prediction in the case of egg components as it was already reached in the case of body composition in different animal species. For this purpose the egg-segmentation software has to be tested with modified algorythms. Further optimization of the measurement parameters might need to be considered as well.
(Keywords: hen, egg, yolk content, computer tomography)

INTRODUCTION

Over a long period of time, elucidation of the correlations between the composition of hatching eggs and the development of the birds hatched was hampered by the lack of instruments that would have been capable of determining the composition of eggs and monitoring the development of embryo within the same egg without opening the egg. Later, *Williams et al.* (1997) made an attempt to determine the chemical composition of eggs without opening them, using the so-called TOBEC method for their study. During their studies conducted with chicken, duck, guinea fowl and quail eggs, they demonstrated a significant positive correlation between the so-called E values measured

by the TOBEC method (the electrical conductivity of the eggs) and the water content of eggs as well as the dry matter content of the albumen in all the four species studied. However, between the E-value and the dry matter content of the egg yolk statistically significant correlations were found only in the case of chicken and quail eggs.

Relying on the results of *Williams et al.* (1997), studies on the composition of hen's eggs using the TOBEC method, without opening the eggs, together with the investigation of correlations between egg composition, hatchability and the development of the birds hatched have recently been started at the Kaposvár University as well. The study demonstrated that, using the TOBEC method – by measuring the electrical conductivity – eggs with a composition markedly different from one another can be distinguished and assorted efficiently. At the same time, the research results have confirmed that eggs of different composition – i.e., having dissimilar yolk/albumen ratios – have significantly deviating hatchability, and that the birds hatching from these eggs have significantly different body composition at the time of hatching and significantly different growth rate during rearing and finishing (*Milisits et al.,* 2008a, 2008b). Thus, these research results clearly show that the composition of hatching eggs markedly influences their hatchability and, furthermore, it has an impact on the quality of the birds hatched and even on their growth rate during the rearing and finishing period. On the basis of all these findings, therefore, it seems to be expedient and justifiable to continue the research in order to determine the correlations between egg composition, hatchability and the development of the birds hatched in a more accurate manner. Namely, the biggest disadvantage of the above-mentioned TOBEC method is that, because of the only moderate correlation found between the electrical conductivity and the composition of eggs, it is not suitable for demonstrating minor changes in egg composition, and is reliable only for distinguishing eggs with extremely divergent composition (*Milisits et al.,* 2007). Therefore, in a former experiment, the applicability of computer tomography (CT) was tested for the *in vivo* prediction of the composition of hen's eggs.

However, in that study it was pointed out that the evaluation of the CT images based on the X-ray density values of the pixels (picture elements) resulted only in a very low correlation between the measured yolk weight and the estimated yolk volume (*Milisits et al.,* 2009). Therefore, as another method of the evaluation, the surface of the egg yolk was determined manually on the cross-sectional CT images, which resulted in a much better accuracy of prediction, depending on the number of scans involved in the prediction equations (*Milisits et al.,* 2009). However, because this evaluation method is very time-consuming, a new egg-separation and segmentation software was developed for the automatic determination of egg yolk volume on the CT images obtained. Therefore, the aim of this study was to examine, whether the accuracy of prediction of the egg yolk content can be influenced by changing the technical parameters of the CT scanning procedure.

MATERIALS AND METHODS

As first step of the study, CT examination of 120 eggs – originating from a dual-purpose TETRA-H parent stock – was carried out in order to develop the measurement protocol and to determine the correlations between the information content of the CT images and yolk content of the eggs. The CT examinations were performed by a Siemens Somatom Emotion 6 multislice CT scanner, based at the Institute of Diagnostic Imaging and Radiation Oncology of the Faculty of Animal Science at Kaposvár University.

Before the scanning procedure eggs were weighed and positioned for the scanning in standing/upright position. During the CT measurements eggs were positioned in egg

holders (10 eggs), thus two eggs were scanned simultaneously. Altogether 9 scanning settings were tested, where the tube voltage and the X-ray radiation dose were 80 kV–40 mAs, 80 kV–80 mAs, 80 kV–120 mAs, 110 kV–40 mAs, 110 kV–80 mAs, 110 kV–120 mAs, 130 kV–40 mAs, 130 kV–80 mAs, 130 kV–120 mAs. At all of these settings 3 mm thick overlapping slices were taken from the eggs using the following technical parameters: spiral mode, pitch 1, field of view 110 mm. The images obtained were analysed by a new self-developed egg-separation and segmentation software. With the help of this software the border of the shell and albumen and the border of the albumen and yolk was determined and the volume of the yolk was calculated thereafter.

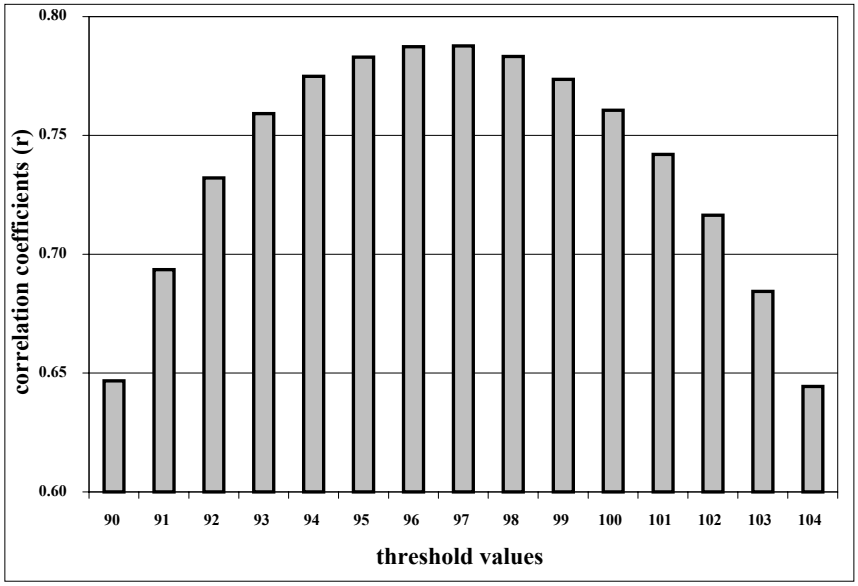
After the CT measurements all of the eggs were broken and their yolk and albumen were separated. After weighing the yolk, its ratio to the whole eggs was calculated. For the determination of correlations between CT predicted yolk volume and measured yolk weight Pearson correlation coefficients were calculated using the SPSS statistical software package (*SPSS for Windows,* 1999).

RESULTS AND DISCUSSION

Because the newly developed egg-separation and segmentation software is based on finding the border between shell and albumen and albumen and yolk, the first step of the evaluation was the determination of the strongest correlation between predicted and measured egg yolk content depending on the applied threshold values for separating the different egg components. As a result of this evaluation it was found that the use of the value 97 resulted in the most accurate separation of albumen and yolk, i.e. in the highest correlation between the predicted and measured yolk content of the eggs (*Figure 1*).

Figure 1

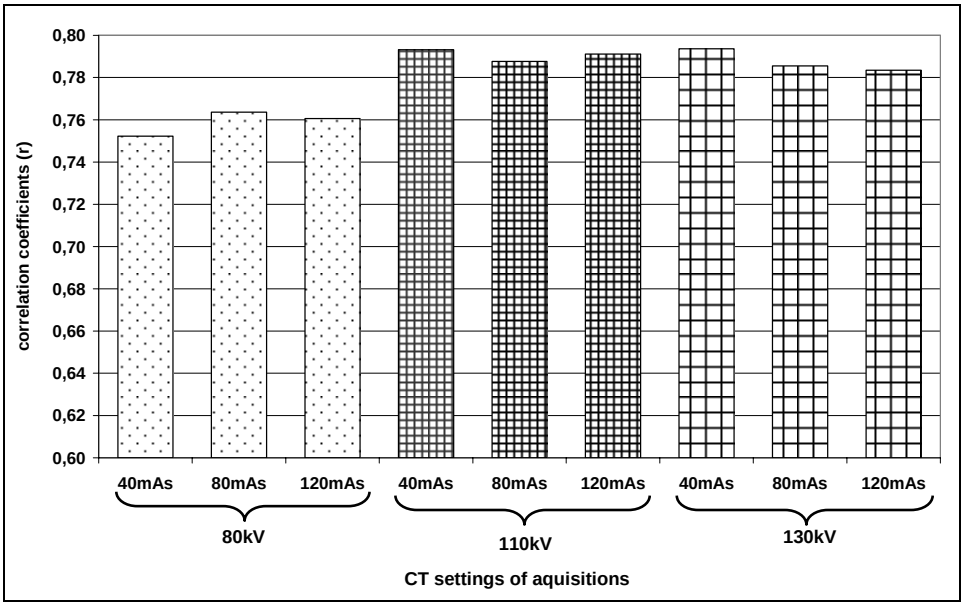
Correlations between CT predicted and weighed egg yolk content of hen's eggs using different threshold values in the image evaluation



Therefore, the further evaluation of the effect of different measurement parameters on the predictability of the egg yolk content was based on using this threshold value. Using this semiautomatic evaluation process it was established that the higher tube voltage settings of 110 and 130 kV resulted in higher correlation coefficients (r=0.78–0.79), than the lower voltage setting of 80 kV which had only an 0.75–0.76 "r" value between the CT predicted yolk volume and the measured yolk weight. The X-ray dose (mAs) had no significant effect on the examined correlation coefficients (*Figure 2*).

Figure 2

Correlations between the CT predicted yolk volume and the measured yolk weight depending of the CT acquisition parameters



CONCLUSIONS

Based on the results it was concluded that the obtained correlation coefficients were lower than it was expected, but they were better than in a former experiment using the TOBEC method. It is likely, that further modification of the aquisition parameters is needed using more scans – smaller slice thickness – covering the eggs during the measurement procedure. The other possible way of the development could be the adaptation of new algorithms into the egg-separation and segmentation software, which could increase the correlation between the estimated and measured egg yolk content.

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