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In vivo investigation of fatty goose liver by means of CT

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ABSTRACT

Commercial geese (Gray Landes) were examined by means of high resolution spiral computer tomography. Three ganders were scanned six times before (1), within (2-5) and after (6) the force-feeding period. 25-40 serial CT images were taken depending on the liver size. The changes in the volume of the liver and also the characteristic Hounsfield values were determined. The mean values of volume (cm^3) were 149, 156, 234, 424, 625, 180 at the 1, 2, 3, 4, 5, 6 measuring times respectively. The characteristic X-ray density values of the liver (75-85, 80, 80, -20, –50 and 55 at the 1, 2, 3, 4, 5, and 6 period respectively) were given in Hounsfield units. The applied in vivo method may be a suitable way to study the quantitative changes of the liver and also to describe the qualitative changes of tissue composition during the force-feeding period.

(Keywords: goose liver, computer tomography)

INTRODUCTION

One of the main objectives of goose breeders is to maximize the accesible liver volume during the force-feeding period and also keep its fat content at the optimum level for the further processing industry and the consumers. Under natural conditions some degree of hepatic steatosis occurs in the wild waterfowl, as a consequence of energy storage before the migration. In poultry production, this specific capacity is utilised for the production of commercial fat liver. The excess of triglicerides is normally stored in the cytoplasmic storage vesicles of the liver. When overproduction of triglicerides occurs, which is the case during force feeding, the liver responds in two ways: the secretion of triglycerides into plasma as VLDL increases and since the force feeding does not allow the birds to be fasted, the liver continues to accumulate triglicerides (*Scahaw*, 1998).

It is well known that geese breeds differ in their susceptibility to liver steatosis considering that the response to force-feeding is partly under genetic control (*Hermier et al*., 1991). According to *Rouvier et al.* (1992) the direct genetic effects due to autosomal and sex linked genes were high and positive for fatty liver weight in selected strains of geese. It is notable that the liver weight could be increased by selection without a great effect on “paletot” weight as *Larzul et al*. (2000) established. The Landes goose – used in the present study – is among the best in response to overfeeding as described by *Mourot et al.* (2000). To a certain extent the high susceptibility of the breed is explainable with the high activity of malic enzyme and also with the fact that hepatic lipogenesis remains very active until the end of the overfeeding period to be used to improve the quality and quantity of the liver produced by geese.

At present our experiments are focusing on the preliminary step (preparation) of the force-feeding and the development of new selection methods (*Bogenfürst*, 1992). In such research it is often required to measure the body composition, exact volume and composition of organs or tissues before and during the course of the experiment. It would be ideal if these measurements could be taken on the same individuals repeatedly, using non invasive in vivo methods. Conventionally the lipid content of the liver can be measured by direct chemical analysis. According to *Guy* (2000) the total lipid content of the fatty goose liver is around 50-55%. Storage lipids are predominante, with 95% triglycerides and 1-2% cholesteryl esters. Structural membrane lipids, such as phospholipids and free cholesterol, account for only 1-2 and <1%, respectively (*Fournier et al.,* 1997). The force-feeding induces a large hypertrophy of hepatic cells in relation to the accumulation of the triglycerids. In spite of the highest liver weight, geese provide the best technological liver quality with a fat loss limited to 13.9% during autoclaving astablished *Guy* (2000).

Regarding to *Molette et al.* (2001) the near infrared reflectance spectroscopy can be a new instrumental method in the prediction of the chemical composition of goose fatty liver. There is no data in the literature about the application of *in vivo* methods in this regard of goose research.

In studies with chicken (*Bentsen* and *Sehested*, 1989; *Svihus* and *Katle*, 1993), turkey (*Brenoe* and *Kolstad*, 2000) it has been shown that computer tomography (CT) is a suitable non-invasive technique to measure the volume or mass of the Pectoralis muscle and the abdominal fat permitting single or repetitive measurements. *Romvári et al.* (2000) published a new in vivo 3D method to estimate the breast muscle of broiler chickens by computer tomography.

In the present study different in vivo CT methods were tested to follow the liver development of geese and analyse the liver composition during the force-feeding period.

MATERIALS AND METHODS

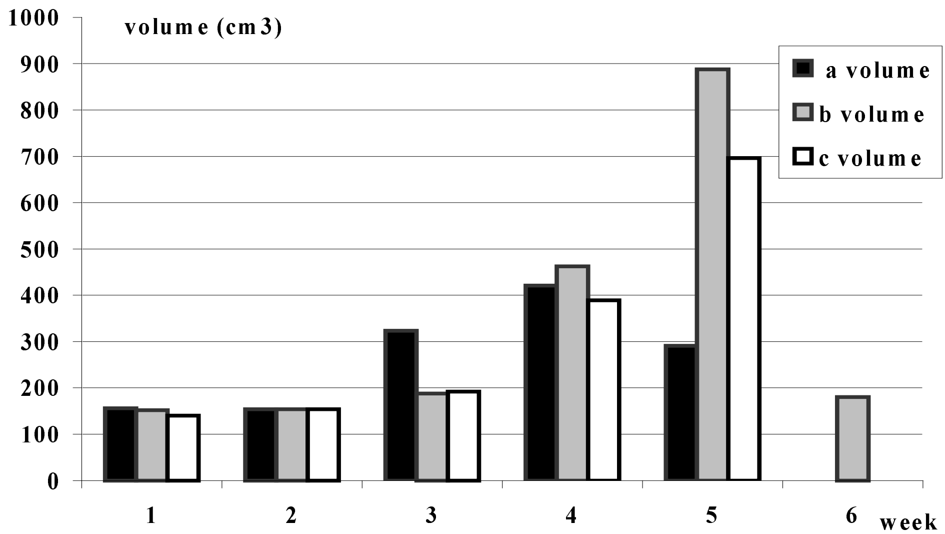
Commercial type Landes ganders were examined at 11, 15, 16, 17, 18, 20 weeks of age (altogether six times) four weeks before (1), within (2-5) and two weeks after (6) the force-feeding period. The three repeatedly examined animals (A, B, C) were selected from a larger population representing the average weight of the given age. The rearing conditions and the nutrition procedure corresponded to the common intensive management technology widely practiced in Hungary. A commercial pelleted goose feed was fed ad libitum. Twenty-eight days before the force-feeding a preparation period was started. During that interval the total daily feeding time was decreased continuously, from twice 60 minutes to twice 30 minutes. At the end of the preparation period birds had only twice 30 minutes acces to feed per day. Later on, as a result of this technological process the gullets of geese were expanded and they were able to consume the same amount of feed during half time for fatty liver production. The ganders were scanned in vivo by means of a Siemens Somatom Plus S40 spiral CT scanner at the Institute of Diagnostic and Oncological Radiation of Kaposvár University. The high resolution CT scans were taken from the geese using a zoom factor of 3.4. During the examination animals were fixed with belts in a plastic cradle without using anaesthetics. Depending on the size of the birds *25* to *40* pictures - with five mm slice thickness - covered the region of the liver. The CT scans were adjusted to take 5 mm thick imaginary slices from the liver. The picture-forming pixels are in fact small prisms with a definite volume. We are able, therefore, to determine the part of the total volume of the examined scan that falls into the Hounsfield (HU) interval of interest. Two kinds of picture evaluation method were applied. As a first approach the liver volume data were determined from the series of cross sectional images. Parallel to this the average Hounsfield value of the liver tissue was also measured. The crude fat content of the liver was determined by direct chemical analysis from „A” and „C” birds following the force feeding period.

RESULTS AND DISCUSSION

There was no negative effect of CT scanning on the liver development, as the final liver volume at the end of the force feeding (period 5) was similar to the rest of the geese from the original stock. Substantial changes were observed in the liver volume within the examined period (*Figure 1).*

Figure 1

Changes of the liver volume



At the time of the preparation (1) and the beginnig of force-feeding (2) the measured values were similar. At the end of the 21-day period (5) the volume data became three times higher compared to the starting point. Two weeks later, as a consequence of feed withdrawal „B” bird approached its starting weight. Similar observation was done by *Prehn* (1996) monitored the fate of birds which returned to basic conditions within an approx. four weeks after reaching the terminal stage of force feeding. After the early rapid increase (3) the “A” bird showed a fallback in liver tissue development (5) caused by its individual susceptibility for the force feeding, which resulted in a fatal gastro enteritis.

In addition to the quantitative evaluations a certain qualitative analysis of the liver was also performed. The goose liver tissue has a characteristic X-ray density value (around 80 HU) in its normal, physiological status. Substantial changes can be seen on *Figure 2, 3* and *4* in the HU values throughout the period.

Figure 2

Changes of the characteristic HU values of the liver within the examined period in C bird

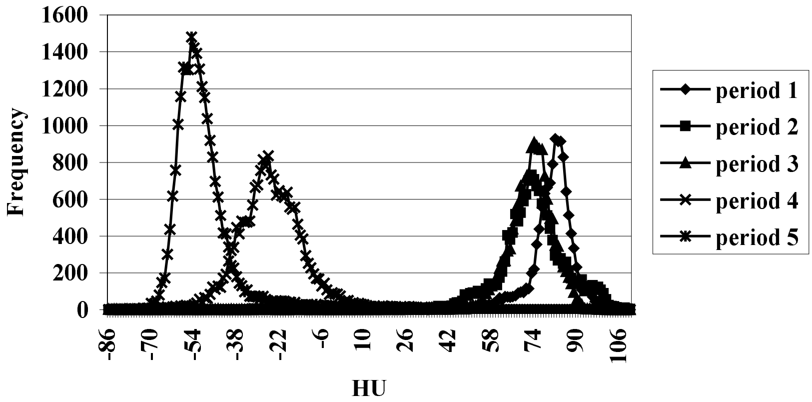


Figure 3

Changes of the characteristic HU values of the liver within the examined period in B bird

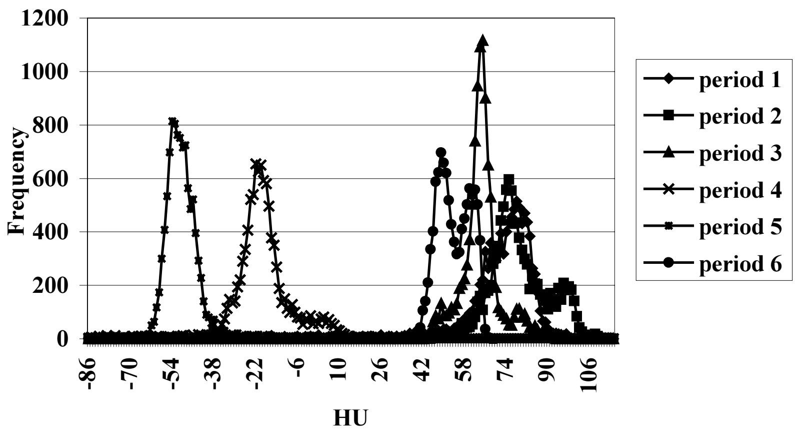
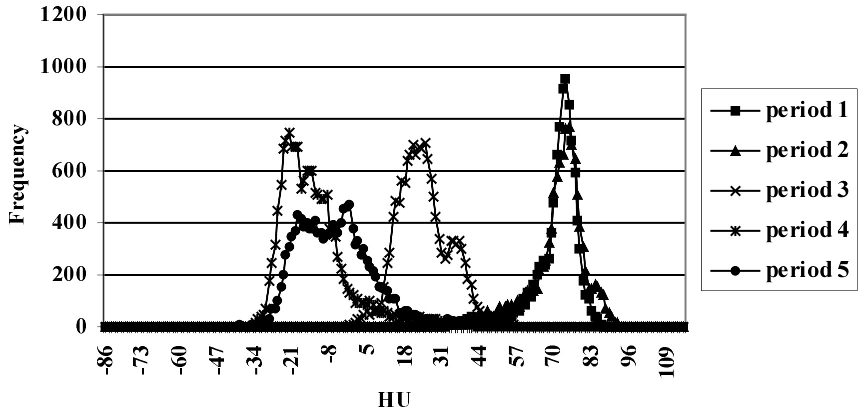


Figure 4

Changes of the characteristic HU values of the liver within the examined period in A bird



Similarly with the volumetric changes the measured density values sensitively follow the force feeding process. The average characteristic HU values of the three examined goose are nearly similar within the period of preparation (1-2) and post force-feeding (6) (55-80 HU). In the course of force feeding (2, 3, 4 and 5) the density values were 80, 80, -20 and -50 HU respectively. The latter value approximates the typical fat tissue density, referring to the high fat content of the fatty liver.

At the end of the force feeding the crude fat content of the liver was determined in bird „A" and „C". The measured 37 and 52% fat content coupled with 0 és -50 HU respectively. In certain cases the fat deposition becomes irreversible together with the depreciation of the product. According to *Bogin et al.* (cit SCAHAW, 1998) if the force feeding is continued after three to four days, the level of cell damage rises significantly. In Hungary 6-10% of the processed fatty livers show the so called extreme fatty liver syndrome.

While the liver substance is relatively constant, a few CT scans seem to be sufficient to grade the fatty liver. The large variation in the characteristic HU values corresponding to the different liver tissue composition encourage the development of direct *in vivo* evaluation methods. Based on this fact experiments are in progress to calibrate our CT method to predict the fat content of the liver. As a complementation MR spectroscopic procedure can be applied to define the final step of the liver cell degradation, are under way. Liver tissue samples taken with biopsy from the living animals provide the examination of cell wall damage, finding the point where the process turns into an irreversible one.

CONCLUSIONS

The applied in vivo CT examination method seems to be suitable to follow the liver development and analyse the liver composition of geese during the force feeding period. It seems wortwhile to incorporate this non- invasive method in the selection procedures, or screening of top breeder candidates at least to get own performance data on liver development. These non-invasive procedures harmonize well with animal examination regulations and animal welfare phylosophy.

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