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Morphological and histological characteristics of goose fatty liver

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Abstract

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A study related to the qualification of 399 samples fattened liver of geese was conducted. Marketable fatty liver of grade A constitutes 70.17% with an average weight of 585.0±7.4 g, and grade B – 16.04% with 527.3±9.3 g. The non-marketable liver of grade C (less than 400 g – not considered for foie gras) and unfattened liver make up respectively – 11.03% and 2.76%. Histology observation of livers of qualities A and B showed that the cytoplasm of all hepatocytes contained many fatty droplets in different size which fill the entire cell. The cell plasmalemma in livers with grade A was intact, despite intense fatty infiltration, while in grade B in some cases, integrity was compromised.

Keywords: geese; force feeding; cramming; foie gras; histostructure of liver

Introduction

Fatty liver (known as foie gras) is a product made from geese and mule ducks after force feeding with corn. Goose foie gras is preferred and more expensive from that of mule ducks. It has a more subtle flavor and refined taste. It is not uncommon for roasted or marinated duck meat or fattened liver pass as goose products in restaurants and retail outlets (Mok, 2014; Cai, 2017; Bognar et al., 2018; Zhao et al., 2020). Goose fatty liver is hailed as one of three delicious foods in the world as caviare, Black mushroom by the occidental (Qu Hao & Wang Ji-wen, 2003; HouDahai et al., 2011). The technology for producing foie gras is ancient. The first reports of forced feeding of geese date from the time of Ancient Egypt and Mesopotamia – about 2500 BC. Earlies evidences are the found images in the Mereruka tomb and archaeological artifacts in the valley of the Tiger and Euphrates rivers. Later, this technology was spread throughout Ancient Greece and Roman Empire (Guemene & Guy, 2004; Gerzilov, 2017). In France, foie gras is recognized as being part of the Protected Cultural and Gastronomic Heritage according to Code rural et de la pêche maritime – Article L654-27-1 (Anonimous, 2006 a) and in Hungarygoose liver has received the distinction “Hungaricum”: a unique product to which Hungarians attach great importance (Eurofoiegras, 2020). In Bulgaria, the force feeding of geese began in the late fifties and early sixties of the last century, when the first export of 400 kg of fatty liver was made. Hungary and Bulgaria are currently ranked second and third in the production of foie gras from palmipeds after the global leader France. Generally, over 90% of world foie gras production is in the EU. Approximately 24 500 t of foie gras was produced in the European Union in 2018 – 22 600 t of duck foie gras and 1 900 t of goose foie gras (Euro foie gras, 2020).

The purpose of our study is to establish the influence of force feeding on the growth performance and histostructure of the fattened liver depending on its grade.

Material and Methods

Sampling for assessment. In the licensed slaughter house"Brezovo" Ltd in the region of Plovdiv, 399 cramming Hungarian geese were slaughtered, cut up and their livers evaluated and graded.

Birds, rearing, feeding. The growing goslings (from 0 to 90 days of age) were housed in a free-range raising system (in indoor barn with deep bedding with a yard for walk, shallow water pools and canopies) i.e. a housing system fully ensuring their well-being. Its were fed *ad libitum* with diets consist ME – 11.5 MJ/kg and CP – 18.50% during the starter period (0-28-days of age) and ME – 11.30 MJ/kg and CP – 15.50% during the finisher period (29–90-days of age). In the fattening phase (gavage)with a duration of 15 days, geese were housed in collective cages in building and cramming with yellow corn with daily frequency from 2 times in the start to 5 times in the end (Figure 1). During the 15 day fattening period, 11 geese were tagged and weighed randomly.

Categorization of the liver. The fattened liver was categorised by qualified staff, depending on its weight and structure, as follows:

The grade of the fatty liver was determined by qualifying professionals. Its were divided into appropriate classes according to weight and structure, as follows:

- Grade A – the best quality and the largest size, with a smooth surface,no injury, pink cream-coloredwithout hematomas and visible blood vessels, weight over 400 g. Grade A is subdivided into A_{400} (from 400 to 599 g), A_{600} (from 600 to 799 g), A $_{800}$ (from 800 to 899 g), and A_{900} (over 900 g);
- Grade B – fattened liver,pink-cream to pale gray-colored, allowed on the surfaceup to 1-2 small cuts, hematomas, lacerations, patches and blood vessels (with external veins), weightover 400 g.Grade B is subdivided into B_{400} (from 400 to 599 g), A_{600} (over 600 g);
- Grade C – the liver meets the gradeA or B, but without the required weight – under 400 g. It is not a commercial product. According to Regulation 32/2006 article 6a para 3 this liver is classified for processing (Anonymous, 2006, b);
- Cull (Waste) – unfattened liver, the process of steatosis is incomplete, color uncharacteristic, with external surface changes (thick zipper, spots).

Histological examination. Along with the categorization of each liver, 10 samples from each grade were collected from the right lobe of the parietal surface (pieces 0.8×0.8×0.8 cm of size) for histological study. The liver pieces were fixed in fresh Bouin's fixative for 72 h. Then the fixative was removed in ascending alcohol series (60, 70%, 80%, 90%, 96% ethanol and two times in absolute ethanol at room temperature for 30 min each), specimens were cleared in xylene, embedded in paraffin, cut on a Reichert microtome. Sections 6 µm thick were mounted on glass slides and stained with hematoxylin/eosin. Histological examinations were performed with Jenaval light microscope, and findings were documented with a camera (CETI, Belgium).

Statistical analysis.The results are presented as mean±SEM. Statistical processing of data was done using Student's t-test (StatMost for Windows) and the differences were considered significant at P<0.05.

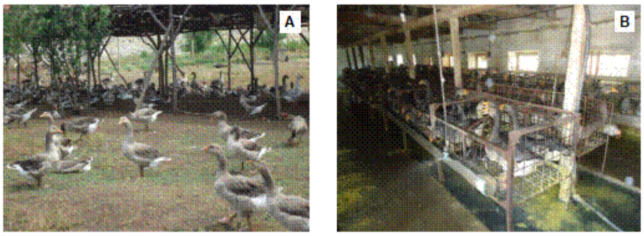

Fig. 1. Geese in growing phase (A) and in fattening phase (B)

Results

It was found that the live weight increased from 4.946 ± 0.097 kg to 7.077 ± 0.102 kg, ie. with 2.132 ± 0.131 kgduring their 15-day cramming period.The consumption of corn was 10.329 kg/ bird and the daily consumption is shown in Figure 2.

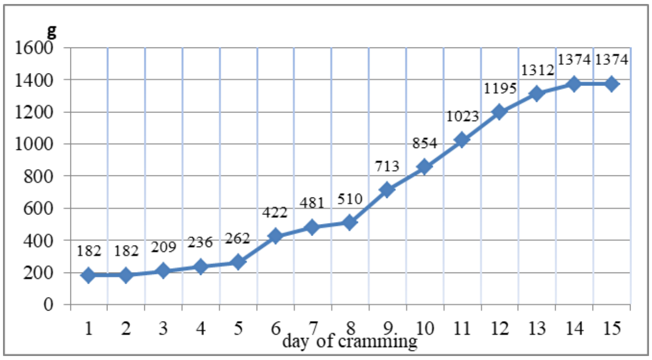

Fig. 2. Daily consumption of corn from goose

The 399 qualified livers were divided according to weight and structure, as follows:

- Grade A –70.17% (280 pcs), average weight 585.0±7.4 g;
- Grade B –16.04% (64 pcs), average weight 527.3±9.3 g;
- Grade C –11.03% (44pcs), average weight355±4.5 g;
- Culled (Waste) – 2.76% (11pcs) with insufficient statuses.

Fatty livers after goose force feeding grade A and B were 86.21% (344 pcs) from total quantity. The distribution of the livers with grade A according to the mass was as follows: A_{400} – 41.85% (167 pcs), A_{600} – 24.31% (97 pcs), A_{800} – 2.76% (11 pcs) and A_{900} – 1.25% (5 pcs). The division of the livers grade B was respectively B_{400} – 12.78% (51 pcs) and B_{600}– 3.26% (13 pcs) (Figure 3).

Histological findings of birds from the group of foieg ras

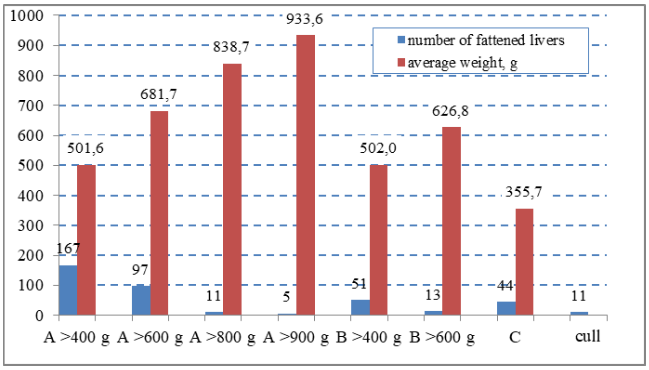

Fig. 3. Grade distribution of livers

grade A show edmorphological features specific for generalized hepatic steatosis (Figure 4). Multiple fatty droplets of various sizes were present in the cytoplasm of hepatocytes, occupying the entire body of cells. Plasmolemmas of cells were however intact regardless of intense fatty infiltration. The margins of glandular tubules and strongly narrowed intravenous sinusoid capillaries were relatively distinct. The nuclei of hepatocytes were round, with signs of nuclear pyknosis.

The liver histology of birds from the foie gras grade B group exhibited signs of massive fatty infiltration of hepatocytes. Compared to the grade A group, relatively large fatty droplets prevailed in the hepatocytic cytoplasm. In single cases, the integrity of cellular membranes was impaired, resulting in indistinct boundaries among glandular tubules.

Light microscopic findings of liver from the group of foie gras grade C were largely similar to that of grade A.

Birds whose liver was culled did not show signs of hepatic steatosis. Hepatocytes were of relatively small size, without signs of hypertrophy. Only single hepatocytes contained 1 to 3 relatively small intracytoplasmic lipid droplets. Acidophilic cytoplasm surrounded relatively large, round, chromatin-depleted nuclei. The boundaries among the cells within glandular tubules as well as among the separate tubules were well visible.

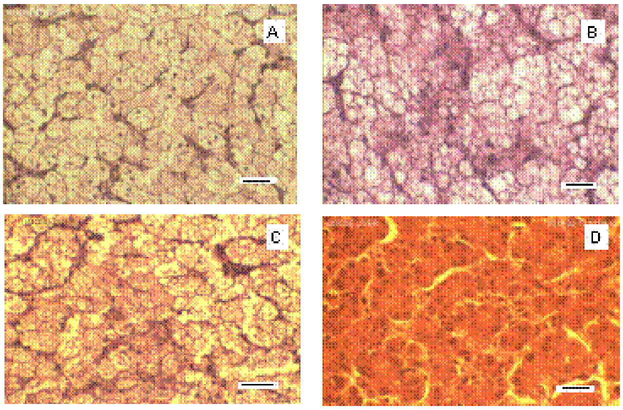

Fig. 4. Liver grade A – (A); liver gradeB – (B); liver grade C – (C) and liver grade„culled" – (D) (H&E; Bar=200.4 µm)

Discusion

The average weight of the fatty liver after 22 days goose force feeding with corn is increased more than 8 times, from 64 g to 518 g (Locsmándi et al., 2005). Later in another study Gerzilov & Petrov (2014) found that liver is increased from 93±4 g to 568±44 g (6.11times) at a 15 day fattening geese.

In the nature, hepatic steatosis occurs spontaneously in some fish and birds includingwaterfowls as a result of energy storage before migration,and can also be induced by over feeding (Pilo & George, 1983; Locsmándi et al., 2005; Hérault et al., 2010).This process is facilitated in these egg-laying species because lipo-neogenesis takes place in the liver. In other words, nutritionally induced steatosis results from liponeogenesis, whereby excess carbohydrates are transformed mainly into triglycerides that are "stored" in the liver. They account for about 95% of the total lipid content of the fatty liver (Hermier et al., 1988, 1999 a,b; Fournier et al., 1997; Baeza et al., 2013). Mastery of this mechanism – for a short periodof time to be accumulating fat in the liver is underlies the fattening of geese and ducks. It is suggested that fatty liver is physiologically reversible, after ending of force feeding, which proved that fatty liver is a kind of healthy and safe foodstuff (Chen Wei-hu et al., 2010).

Locsmándi et al. (2007) were performed a study about characteristic physiological alterations by means of computer tomography, and histology of the liver, during force-feeding of 30 Landes geese at 18-day long period. Samplingswere performed at the start and during force-feeding (7th, 11th, 14th, 18th days). Computer tomographic data were plotted in 3D histograms, effectively indicating the volumetric development and the fat deposition of the liver. Histological sections indicated the appearance of microvesicular fat forms in the hepatocyte cytoplasm, which first turned to a total fatty infiltration, later changing to a macrovesicular form with progressing inflammation; membrane damage was not visualized.

Conclusion

The study shows that 86.21% of geese produce high grade fatty liver of grade "A" and "B" at 13 day long period of cramming with corn.

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