The effect of temperature and length of storage on the formation of biogenic amines and polyamines in the muscle tissue of eviscerated pheasants (*Phasianus colchicus*)

Zdeňka Hutařová[1], Iva Steinhauserová[2], Vladimír Večerek[1], Gabriela Bořilová[2], Petr Maršálek[1]

[1]Department of Veterinary Public Health and Toxicology
[2]Department of Meat Hygiene and Technology
Faculty of Veterinary Hygiene and Ecology
University of Veterinary and Pharmaceutical Sciences Brno
Brno, Czech Republic

Abstract

Biogenic amines are found in a large number of foodstuffs. Ingestion of a large quantity of biogenic amines in food may produce negative toxic symptoms in humans. Biogenic amine concentrations in meat are associated with the proliferation of contaminating microorganisms. An increasing concentration of biogenic amines serves as an indicator of the deteriorating hygiene quality of the meat and as an indicator of meat spoilage during storage. It has been found that the biogenic amines cadaverine, putrescine and tyramine may be considered the main indicators of the hygiene quality of the meat of eviscerated pheasants killed by pithing. From the viewpoint of the concentration of biogenic amines, such pheasants can be stored at a temperature of 0 °C for a period of 14 days, after which time the concentration of biogenic amines in the meat begins to increase. When pheasants are stored at a temperature of 15 °C, the increase in the concentration of biogenic amines begins during the first days of storage. The growth of biogenic amines is greater in leg muscle than in breast muscle. The leg muscle of eviscerated pheasants is, therefore, a food product posing a greater risk from the viewpoint of the content of biogenic amines.

Game, eviscerated pheasant, biogenic amines, hygiene quality, storage

Introduction

Biogenic amines are organic nitrogen compounds with an aliphatic, aromatic or heterocyclic structure that are found in a large number of foodstuffs. Although biogenic amines are essential for many functions in the human organism, the consumption of foodstuffs containing large quantities of biogenic amines leads to a number of toxicological effects (Santos 1996). The formation of biogenic amines in foodstuffs is primarily associated with the action of microbial decarboxylase enzymes (Santos 1996; Shalaby 1996; Hernández-Jover et al. 1997; Vinci and Antonelli 2002; Standarová et al. 2012). An increase in the concentration of biogenic amines in foods is associated with the growth and metabolism of contaminating microorganisms (Hernández-Jover et al. 1997). The concentration of biogenic amines in foods can, therefore, serve as an indicator of microbial contamination, and is therefore suitable for determining the level of food spoilage (Vinci and Antonelli 2002).

Today, game is a widely available foodstuff (Standarová et al. 2012) that is becoming increasing popular with consumers. The common pheasant is a game species that has been bred in the Czech Republic for centuries. While pheasants as a game species were formerly associated primarily with hunting, the farm breeding of pheasants for slaughter and meat production is now becoming increasingly important (Hofbauer 2010). The quality of game meat depends to a considerable extent on the method of treatment following death. The recommended method for treating pheasant carcasses is the complete evisceration of the organs of the body cavity through an opening created by a short cut from the cloaca in the direction of the breastbone (Winkelmayer et al. 2004).

Our study aimed to assess the effect of storage conditions (temperature and period of storage) on the hygiene quality of the meat of eviscerated common pheasants.

Address for correspondence:

MVDr. Zdeňka Hutařová
Department of Veterinary Public Health and Toxicology
Faculty of Veterinary Hygiene and Ecology
University of Veterinary and Pharmaceutical Sciences Brno
Palackého tř. 1/3, 612 42 Brno, Czech Republic

Phone: +420 541 562 789
E-mail: hutarovaz@vfu.cz
www.maso-international.cz

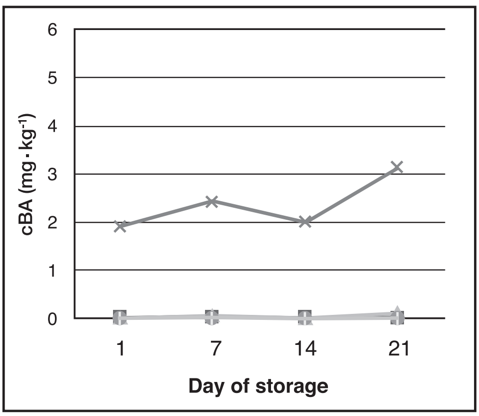
Storage took place at temperatures of 0 °C and 15 °C. The lower of these temperatures is widely used for storing pheasants. The temperature of 15 °C used in the study simulated the storage of pheasants outdoors and the situation occurring when refrigeration equipment breaks down.

Materials and Methods

Fourty common pheasants killed by severing the spinal cord and subsequent destruction of the brain were used for the purposes of the study. This method of killing the pheasants was chosen to simulate the situation during the slaughtering of birds on farms. The pheasant carcasses were subsequently treated in the recommended fashion, i.e. the complete evisceration of the organs of the body cavity. Two groups of 20 pheasant carcasses were then placed in separate refrigerators preset to temperatures of 0 °C and 15 °C. Samples of breast and leg muscle were then taken at weekly intervals (on days 1, 7, 14 and 21 after death) from 5 pheasant carcasses in each group for the purpose of determination of the concentration of selected biogenic amines (putrescine, cadaverine, histamine, tyramine, tryptamine, 2-phenylethylamine, spermine and spermidine). Samples for analysis were prepared by tissue extraction with a 5 % solution of trichloracetic acid. Analysis was performed by the liquid chromatography method with tandem mass spectrometry. The results were processed and statistically evaluated in the statistical program UNISTAT 5.6 using the Kruskal-Wallis test.

Results

The resultant average levels of biogenic amines determined in eviscerated pheasants stored at a temperature of 0 °C are given in Figure 1 (concentration in breast muscle) and Figure 2 (concentration in leg muscle).



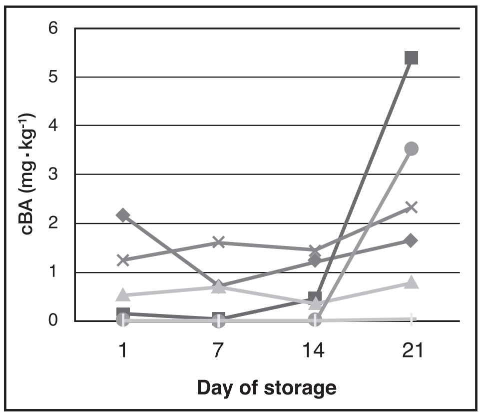


Fig. 1. Concentration (mg.kg^{-1}) of biogenic amines in the breast muscle of eviscerated pheasants stored at a temperature of 0 °C throughout the storage period (Days 1, 7, 14, 21)

Fig. 2. Concentration (mg.kg^{-1}) of biogenic amines in the leg muscle of eviscerated pheasants stored at a temperature of 0 °C throughout the storage period (Days 1, 7, 14, 21)

It can be seen from the given results that the concentration of biogenic amines in the breast muscle of pheasants stored at 0 °C did not change significantly during the storage period. In the case of the leg muscle of pheasants stored at 0 °C, a statistically significant increase was seen in the concentrations of the biogenic amines cadaverine (to 5.39 mg.kg^{-1}

on day 21) and tyramine (to 3.51 $mg.kg^{-1}$ on day 21) ($P \leq 0.05$), as well as an increase in the concentration of putrescine (to 1.66 $mg.kg^{-1}$ on day 21) that was not, however, statistically significant. The most pronounced changes were recorded between days 14 and 21 of storage. The polyamine spermine occurred at high concentrations from the beginning of storage (within a range of 45–59.4 $mg.kg^{-1}$ in breast muscle and 27.8–35.1 $mg.kg^{-1}$ in leg muscle).

The resultant average concentrations of biogenic amines determined in pheasants stored at a temperature of 15 °C are given in Figure 3 (concentration in breast muscle) and Figure 4 (concentration in leg muscle).

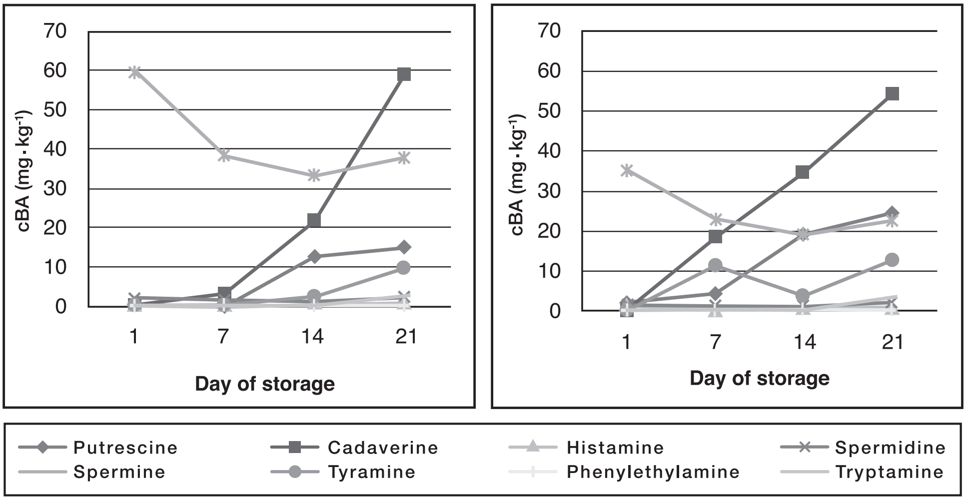


Fig. 3. Concentration ($mg.kg^{-1}$) of biogenic amines in the breast muscle of eviscerated pheasants stored at a temperature of 15 °C throughout the storage period (Days 1, 7, 14, 21)

Fig. 4. Concentration ($mg.kg^{-1}$) of biogenic amines in the leg muscle of eviscerated pheasants stored at a temperature of 15 °C throughout the storage period (Days 1, 7, 14, 21)

Statistically significant changes in concentration during the course of storage were determined in the breast muscle of pheasants stored at 15 °C for tyramine (to 9.55 $mg.kg^{-1}$ on day 21) ($P \leq 0.01$), and also for putrescine (to 14.86 $mg.kg^{-1}$ on day 21) and cadaverine (to 58.85 $mg.kg^{-1}$ on day 21) ($P \leq 0.05$). A highly statistically significant increase in the concentration of tryptamine was also determined ($P \leq 0.01$), which did not, however, exceed values of 2.80 $mg.kg^{-1}$. The most pronounced increase in concentrations was observed from day 7 of storage for cadaverine and putrescine, and from day 14 of storage for tyramine and tryptamine.

In the leg muscle of pheasants stored at 15 °C there was a statistically highly significant increase in concentrations determined during the course of storage for cadaverine (to 54.30 $mg.kg^{-1}$ on day 21) and putrescine (to 24.68 $mg.kg^{-1}$ on day 21) ($P \leq 0.01$). There was also an increase in the concentration of tyramine (to 12.75 $mg.kg^{-1}$ on day 21), which was not statistically significant and which fluctuated. A statistically highly significant increase in concentration ($P \leq 0.01$) during the course of storage was also seen for tryptamine, though at values not exceeding 3.25 $mg.kg^{-1}$. The concentrations of cadaverine, putrescine and tyramine increased during the first week of storage, while an increase in the concentration of tryptamine was not seen until day 14 of storage.

Discussion

The results given in Figs 1 to 4 indicate that the most important biogenic amines whose concentration increases during the course of storage of eviscerated pheasants include cadaverine, putrescine and tyramine. An increase of tryptamine, the values of which were, however, negligible, was also seen in pheasants stored at a temperature of 15 °C. A significant increase in the concentrations of cadaverine and putrescine during the course of storage of chicken breast muscle is also described by Vinci and Antonelli (2002). In contrast, a fall in the concentration of tryptamine was discovered in their study during the course of storage of chicken breast muscle. An increase in the concentrations of putrescine, cadaverine and tyramine in chicken breast muscle stored at 4 °C is also given by Balamatsia et al. (2006). Hernández-Jover et al. (1997) state that the sum of the concentrations of putrescine, cadaverine, tyramine and histamine may be used for evaluation of meat freshness. It is clear from the results of our study that the concentration of histamine does not change significantly during the course of storage. In terms of informative value in relation to meat freshness, cadaverine, putrescine and tyramine have a particular informative value in the case of the muscle tissue of eviscerated pheasants.

The results given for the muscle tissue of eviscerated pheasants stored at temperatures of 0 °C and 15 °C also indicate that the content of biogenic amines was higher in leg muscle than in breast muscle from the beginning. At the end of the storage period, the concentrations of cadaverine and tyramine in the leg muscle of pheasants stored at 0 °C were statistically highly significantly higher than in breast muscle ($P \leq 0.01$). Even at a storage temperature of 15 °C, the growth of biogenic amines was earlier and higher in leg muscle than in breast muscle, though the statistical significance of the difference in concentrations at the end of the storage period was not proven. Standarová et al. (2012) describe an opposite finding in their work, with higher concentrations of biogenic amines being found in the breast muscle at the end of storage in non-eviscerated pheasants stored at refrigeration temperatures and outdoor temperatures.

Overall, on the basis of the results we obtained, it can be said that greater and more intensive formation of biogenic amines occurs during the course of storage in the leg muscle of eviscerated pheasants. A possible reason for this is the evisceration method itself, during which the lower part of the body cavity is opened, meaning that it is this area in particular that is predisposed to higher secondary contamination.

This work also indicates that when eviscerated pheasants are stored at a temperature of 0 °C, a loss of hygiene quality (particularly in the leg muscle) is seen after 14 days of storage. When eviscerated pheasants are stored at a temperature of 15 °C, changes to the concentrations of biogenic amines occur extremely rapidly, practically from the beginning of storage. These results indicate that leaving eviscerated pheasants outdoors for the duration of the maturing of the meat is entirely unsuitable. Should a fault occur to refrigeration equipment, it is essential to ensure its immediate repair or to have substitute refrigeration available.

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