The production of biogenic amines in the muscle tissue of eviscerated mallard ducks in dependence on storage time and temperature

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Abstract

The quality of game meat is significantly influenced by the way in which the animal is treated after killing. The recommended way of treating mallard ducks is complete evisceration of the organs of the body cavity. The hygiene quality of meat may be assessed on the basis of changes in biogenic amine concentrations, an increase which is associated with the proliferation of contaminating microflora and a fall in the hygiene quality of the meat. In our work, we studied the content of biogenic amines in the meat of harvested mallard ducks treated by evisceration of the organs of the body cavity and stored for a period of 21 days at temperatures of 0 °C and 15 °C. We found that the most important biogenic amines for the evaluation of the hygiene quality of mallard duck meat are cadaverine, putrescine and tyramine. Changes in biogenic amine concentrations occurred in the very first days of storage at both 0 °C and 15 °C. In ducks stored at 0 °C, the content of biogenic amines was higher in the thigh muscle, while higher concentrations were found in the breast muscle of ducks stored at 15 °C (the difference was not, however, statistically significant). Overall, these results indicate that the recommended length of time for which harvested and eviscerated mallard ducks can be stored at 0 °C is extremely short (1 or 2 days), and that their storage at 15 °C cannot be recommended at all in view of high concentrations of biogenic amines.

Biogenic amines, mallard duck, evisceration, storage, hygiene quality

Introduction

Game and game dishes are becoming increasingly popular with consumers. The principal reasons for this are their easy digestibility, their more tender muscle fibre and lower fat content, and a higher proportion of unsaturated fatty acids in comparison with livestock animals. The quality of game meat is closely associated with the method of hunting and subsequent handling. Treatment of game after hunting is one of key factors in terms of ensuring the hygiene quality of the game. The recommended method of treating game after hunting is, for wild waterfowl game species, the complete evisceration of the organs of the body cavity through an opening made by a small cut from the cloaca in the direction of the breastbone (Winkelmayer et al. 2004). In contrast to other wild game animals, it is not recommended to leave the carcasses of mallard ducks to mature. The recommendation for mallard ducks is to hang them in the feathers for one or two days in a cold environment and then to cook them immediately. In spite of this general recommendation, however, we still come across cases in which the carcasses of mallard ducks are stored for a longer period. One way of assessing the hygiene quality and freshness of meat is the dynamics of the formation and change in concentration of biogenic amines. These nitrogen compounds are formed in raw materials rich in proteins, largely by the action of microbial decarboxylase enzymes. The greater concentration of biogenic amines is, the greater microbial contamination of foodstuffs we can expect (Vinci and Antonelli 2002). Monitoring the concentration of biogenic amines is important not merely in view of its association with the level of microbial contamination, but also in view of the negative effects that these compounds may have on human health following the consumption of foodstuffs containing

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its high concentrations. The aim of this study was to determine the content of biogenic amines in the muscle of mallard ducks, to determine changes in the concentrations of the biogenic amines monitored during the course of storage and to determine differences in the biogenic amine content between breast and thigh muscle.

Materials and Methods

The carcasses of 40 mallard ducks shot during the hunting season in the autumn of 2011 were included in the study. These carcasses were treated by complete evisceration of the organs of the body cavity and subsequently divided into two groups. The first group of ducks (20 birds) was hung in a cooling device with the temperature preset to 0 °C. This temperature was selected in view of its frequent use for chilling and storing game. The second group of ducks (20 birds) was hung in a cooling room with the temperature set to 15 °C. The temperature of 15 °C was selected to simulate outdoor temperatures or a defect to cooling equipment. Samples of breast and thigh muscle were taken at weekly intervals from five ducks in each group for determination of biogenic amines. The total period of storage was 21 days at a temperature of 0 °C and 14 days at a temperature of 15 °C (after which time a considerable degree of decay was evident in the game and further storage was no longer possible).

Samples for analysis were prepared by extracting tissue with a 5% solution of trichloracetic acid. Analysis was performed using the liquid chromatography method with tandem mass spectrometry. The results obtained were processed and evaluated by the statistical program UNISTAT 5.6 with the use of the Kruskal-Wallis test.

Results and Discussion

The average concentrations of biogenic amines determined in the breast and thigh muscle of harvested and eviscerated mallard ducks stored at 0 °C are given in Plate VIII, Figs 1 and 2. Plate VIII, Figs 3 and 4 show the concentrations of biogenic amines in the breast and thigh muscle of eviscerated ducks stored at 15 °C.

It is clear from the results given in Figs 1 and 2 that the greatest changes in concentrations during the storage of ducks at 0 °C were recorded for cadaverine (to 2.83 $mg.kg^{-1}$ on day 21) and tyramine (to 2.13 $mg.kg^{-1}$ on day 21) in breast muscle, and for putrescine (to 1.72 $mg.kg^{-1}$ on day 21), cadaverine (to 6.88 $mg.kg^{-1}$ on day 21) and tyramine (to 5.04 $mg.kg^{-1}$ on day 21) in thigh muscle. These three biogenic amines can be considered as indicators of the hygiene quality of the meat of mallard ducks. Changes in the concentrations of biogenic amines appear earlier in thigh muscle (during the first week) than in breast muscle (during the second week). A pronounced increase of cadaverine is seen in thigh muscle in the first week of storage, with a subsequent fall in the concentration of this biogenic amine. The reason for this fall may be the proliferation of microorganisms using this biogenic amine in their own metabolism (Vinci and Antonelli 2002). In the case of tyramine, for which a change in concentration was observed primarily from the second week of storage, the difference in the concentrations discovered on day 7 and day 21 of storage ($p \leq 0.05$) was statistically significant.

The most pronounced changes in concentrations in the breast and thigh muscle of ducks stored at 15 °C were seen for putrescine, cadaverine and tyramine. A statistically significant increase in concentration was seen in breast muscle for the three given biogenic amines during the course of storage: cadaverine (to 64.23 $mg.kg^{-1}$ on day 14), tyramine (to 16.81 $mg.kg^{-1}$ on day 14) ($p \leq 0.01$) and putrescine (to 4.24 $mg.kg^{-1}$ on day 14) ($p \leq 0.05$). In the case of thigh muscle, a statistically significant change in concentration was seen during the course of storage for cadaverine (to 56.25 $mg.kg^{-1}$ on day 14) ($p \leq 0.05$). Changes in biogenic amines concentrations in breast and thigh muscle stored at 15 °C occurred in the first week of storage.

When the concentrations of biogenic amines in the muscle of ducks stored at 0 °C and 15 °C are compared, it is clear that a considerably higher content was found in ducks stored at the higher temperature. A low temperature inhibited the growth of microorganisms and led to a reduction in the activity of decarboxylase enzymes (Naila et al. 2010).

From Figs 1 and 2, it is also clear that in ducks stored at 0 °C a higher concentrations were attained in thigh muscle than in breast muscle at the end of the storage period. As can be seen in Figs 3 and 4, the opposite situation was recorded in mallards stored at 15 °C, where higher concentrations were attained in the breast muscle as compared to the thigh muscle. No statistically significant differences in the concentrations of any of the three biogenic amines (i.e. cadaverine, putrescine and tyramine) were, however, recorded between breast and thigh muscle. Higher concentrations of biogenic amines in breast muscle as opposed to thigh muscle have been described in studies by, e.g., Standarová et al. (2012) in pheasant muscle and Silva and Glória (2002) in the muscle of chickens.

Polyamine spermine concentrations were considerably higher than those of other biogenic amines in ducks stored at 0 °C, with no significant changes during storage. The concentration of this polyamine was also high from the beginning of storage in ducks stored at 15 °C, and no significant change was recorded during storage. The presence of high initial levels of spermine and spermidine is described by, Balamatsia et al. (2006) in chicken muscle and by Hernández-Jover et al. (1997) in fresh pork and beef. The concentration of spermine was considerably higher than the concentration of spermidine in all cases. The same finding is described in the study by Krausová et al. (2006), which states that higher concentrations of spermine, as compared with spermidine, are typical for foodstuffs of animal origin, particularly meat. Opposite findings are typical of foodstuffs of plant origin (Kalač and Krausová 2005; Krausová et al. 2006).

Biogenic amine concentration may be used to assess the hygiene quality of fresh meat. In the work on the content of biogenic amines in pork and beef, Hernández-Jover et al. (1997) identified putrescine, cadaverine, tyramine and histamine as the principal biogenic amines useful for assessing meat freshness. Our study indicates that the concentration of histamine in the muscle of ducks stored at 0 °C does not change significantly. Changes are evident at a storage temperature of 15 °C, though these changes are extremely small in terms of absolute values.

Conclusions

It is clear from the results obtained that especially cadaverine, putrescine and tyramine can be considered the principal indicators of the freshness and hygiene quality of mallard game. At a lower storage temperature, higher concentrations of biogenic amines were found in thigh muscle. When mallards were stored at a temperature of 15 °C, higher concentrations of biogenic amines were found in breast muscle. On the basis of the results obtained in this study, the use of low temperatures (0 °C) for an extremely short time (1–2 days) can be recommended for storing harvested and subsequently eviscerated mallards. Any long period of storage of eviscerated mallards at temperatures approaching 15 °C is entirely unsuitable from the viewpoint of the concentration of biogenic amines.

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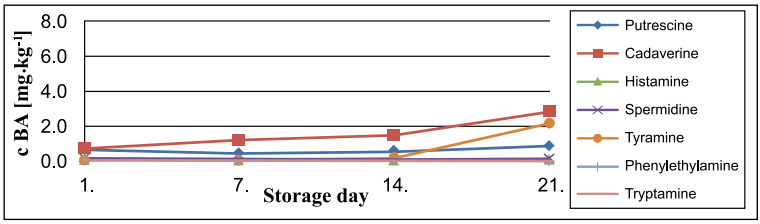

Fig. 1. Concentrations of biogenic amines (mg.kg^{-1}) in the breast muscle of eviscerated ducks stored at 0 °C

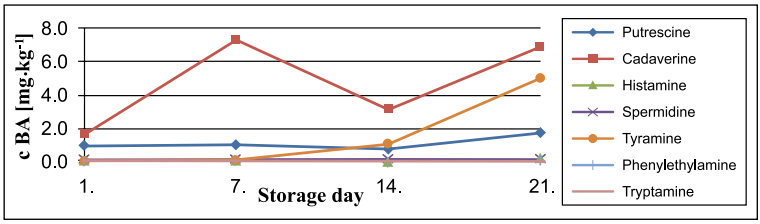

Fig. 2. Concentrations of biogenic amines (mg.kg^{-1}) in the thigh muscle of eviscerated ducks stored at 0 °C

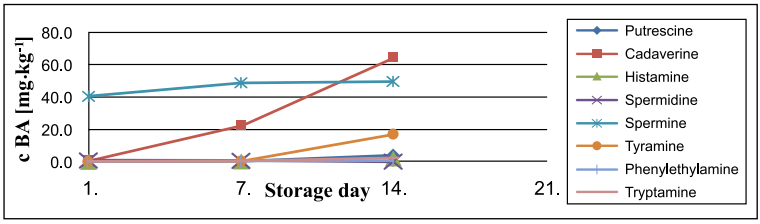

Fig. 3. Concentrations of biogenic amines (mg.kg^{-1}) in the breast muscle of eviscerated ducks stored at 15 °C

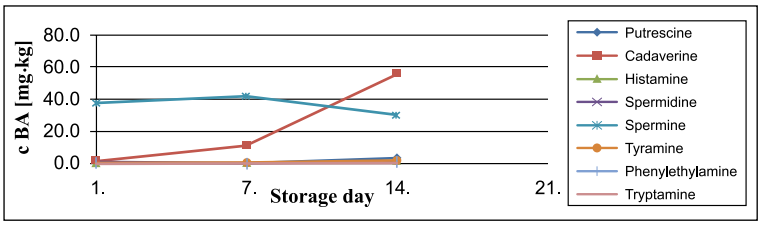

Fig. 4. Concentrations of biogenic amines (mg.kg^{-1}) in the thigh muscle of eviscerated ducks stored at 15 °C